FINAL

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

Upper Animas Mining District

San Juan County, COLORADO

February 2013

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Contract No. EP-W-06-033
DCN: EP8-7-7378

Signature Page – Screening Level Ecological Risk Assessment – Upper Animas Mining District

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LIST OF ACRONYMS

Ag	silver
Al	aluminum
As	arsenic
AUF	area use factor
BAV	bioavailability
BERA	baseline ecological risk assessment
Be	beryllium
BCF	bioconcentration factor
BW	body weight
CCC	criteria continuous concentration
Cd	cadmium
CDPHE	Colorado Department of Public Health and the Environment
CO	Colorado
COPEC	contaminant of potential ecological concern
Cr	chromium
CSM	conceptual site model
Cu	copper
DL	detection limit
EDD	estimated daily dose
EPA	Environmental Protection Agency
EPC	exposure point concentration

ER-L	effects range - low
EU	exposure unit
Fe	iron
FIR	food ingestion rate
ft	feet
HQ	hazard quotient
LOE	line of evidence
mg/kg	milligrams per kilogram (parts per million)
mg/kg.d	milligrams per kilogram per day
mg/kg bw.d	milligrams per kilogram body weight per day
Mn	manganese
Ni	nickel
NRWQC	national recommended water quality criteria
Pb	lead
ROC	receptor of concern
SCM	site conceptual model
Se	selenium
SLERA	screening-level ecological risk assessment
SSL	soil screening level
T&E	threatened and endangered
TEC	threshold effect concentration

TEL	threshold effect level
TRV	toxicity reference value
WIR	water ingestion rate
WP	work plan
WQC	water quality criteria
Zn	zinc

EXECUTIVE SUMMARY

ES.1 Introduction

The Animas River flows through the town of Silverton in San Juan County, CO. This waterway is affected by flow which has come in contact with mineralized material, either naturally or as a result of mining activities, such as through the creation of mine adits. The affected water originates in the upper reaches of the two major tributaries of the Animas River in this area, namely Cement Creek and Mineral Creek, and from other tributaries of the Animas River further upstream of Silverton. The site-related contamination in the tributaries contains high levels of metals and acidity that are carried downstream to the Animas River. This evaluation did not attempt to separate natural contamination from past mining-related contamination, but assessed the risk from all sources combined.

The Animas River in the vicinity of Silverton was divided into two broad sections for the purposes of this Screening-Level Ecological Risk Assessment (SLERA), as follows:

- The reference section is called "the Animas River above Silverton" and refers to the river up to its confluence with Cement Creek in Silverton. Data from the reference sampling location (A68) were collected from the Animas River a few hundred feet upstream of the confluence with Cement Creek. Note that this portion of the river is not called "background" since it is impacted by water that has come in contact with mineralized material via natural processes and past mining activities. It is understood that the chemical and biological conditions in the Animas River above Silverton represent an area of on-going concern. However, this SLERA focused specifically on the Animas River at and below Silverton (see next bullet).

- The impacted section is called "the Animas River at and below Silverton" and refers to the river from its confluence with Cement Creek to an area about 0.5 miles below the confluence with Mineral Creek. This reach covers about 1.5 miles of the Animas River.

The goal of the SLERA was to select Contaminants of Potential Ecological Concern (COPECs) and assess ecological risk to different types of organisms exposed to site-contaminated surface water, sediment, and food, as follows:

- Benthic invertebrates exposed to (a) surface water in mainstem Cement Creek and mainstem Mineral Creek (Note: No recent sediment samples were available from these two waterways), and (b) sediment in the Animas River,

- Fish exposed to surface water in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton, and

- Four wildlife species representing different trophic levels (i.e., avian aquatic insectivore, avian omnivore, avian piscivores, and mammalian herbivore) exposed via ingestion of surface water, sediment, and food items from the Animas River at and below Silverton.

The SLERA was a conservative risk evaluation to identify risk drivers and exposure pathways of concern to community-level and wildlife receptors. The evaluation recognized that mainstem Mineral Creek upstream of the confluence with South Fork Mineral Creek, and mainstem Cement Creek, may not have supported viable fish or macroinvertebrate communities before large-scale mining activities started in the 19th century due to naturally-high levels of metals and low pH levels in their surface waters. These two waterways were nonetheless evaluated in order to provide conservative risk estimates and help identify risk drivers and exposure pathways of concern. It was expected that evaluating these naturally-impaired waterways within a risk-based context would provide information to support a scientific management decision point that needs to be discussed among the state holders before proceeding with a future BERA.

The surface water data represented dozens of samples collected from the three waterways between May 2009 and May 2012. The sediment data consisted of three samples collected from the Animas River above, at, and below Silverton in May 2012. Samples collected during earlier investigations were not evaluated in this SLERA in order to focus on current conditions. The available information was reviewed to identify assessment endpoints and measures of effect, and to develop a Conceptual Site Model (CSM) which showed the movement of contaminants from the sources to the receptors.

The effects evaluation used conservative screening benchmarks obtained from the literature to identify the COPECs in surface water and sediment. These benchmarks, together with no-effect Toxicity Reference Values (TRVs) for birds and mammals, were used to assess the toxicity of the COPECs to benthic invertebrates, fish, and wildlife receptors.

The surface water and sediment COPECs for benthic invertebrates and fish were selected by identifying the metal levels with the highest Hazard Quotients (HQs) using data from May 2009 to May 2012 across the three waterways combined. Those same compounds were also retained as COPECs for the wildlife receptors feeding in the Animas River. However, the waterways were subsequently treated as separate Exposure Units (EUs) to derive the Exposure Point Concentrations (EPCs) for use in the exposure assessment. The exposures associated with surface water were further split into three hydrologic periods, namely the pre-runoff period

(February to April), runoff period (May and June), and the post-runoff period (July to November) (Note: No surface water data were available for December or January).

The exposures by four representative wildlife receptor species feeding in the Animas River were quantified using a simplified food chain model which calculated an Estimated Daily Dose (EDD) based on ingesting surface water, sediment, and food items. No measured tissue residue data were available for those food items, which consisted of aquatic invertebrates, fish, and aquatic vegetation. Instead, the COPECs in the food items were estimated by multiplying the COPEC levels measured in surface water by published COPEC-specific Bioconcentration Factors (BCFs).

Risk was quantified entirely using the HQ method, which compares measured exposures (i.e., surface water and sediment EPCs) or estimated exposures (wildlife EDDs) to corresponding toxicity values (i.e., surface water or sediment screening benchmarks and wildlife no-effect TRVs).

A COPEC-specific HQ was then calculated using the following general equation:

$$HQ = EPC \text{ or } EDD/\text{benchmark or } TRV$$

Where:

HQ	=	Hazard Quotient (unitless)
EPC	=	Exposure Point Concentration (µg/L or mg/Kg)
EDD	=	Estimated Daily Dose (mg/Kg bw.d)
Benchmark	=	surface water or sediment screening benchmark (µg/L or mg/Kg)
TRV	=	wildlife no-effect Toxicity Reference Value (mg/Kg bw.d)

HQs equal to or above 1.0 identified a potential for ecological risk, whereas HQs below 1.0 were used to eliminate chemicals with assurance that they did not pose a risk. Note, however, that HQs > 1 did not mean that risk was unacceptable. Instead, it means that further evaluation may be warranted due to the highly-conservative exposure and toxicity assumptions used in the SLERA.

Besides assessing the potential impacts associated with worst-case (i.e., maximum) exposures, the risk characterization for benthic invertebrates and fish also viewed each surface water sample as an individual exposure event in time. Hence, HQs were calculated for all available surface water samples and were used to form "scatter plots" by sampling station and period. Those plots were then used to identify patterns of risk across the waterways and the three exposure periods.

Uncertainty was inherent in the SLERA because many conservative assumptions were made in order to proceed with the investigation. These assumptions affected all aspects of the assessment including the CSM, the effects analysis, the exposure analysis, and the risk characterization. The uncertainty analysis identified and discussed the major assumptions made in the SLERA. It also provided a short description to determine if each assumption was likely to have overestimated or underestimated the potential for ecological risk. The end result was a balanced overview of uncertainty to help risk managers understand the full extent of potential ecological risk to receptors living or feeding in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton.

ES.2 Risk conclusions for benthic invertebrates

Mainstem Cement Creek: The chemical conditions in the surface water of mainstem Cement Creek were expected to be highly toxic to benthic invertebrates, particularly due to high levels of acidity and dissolved Aluminum (Al), but also due to Cadmium (Cd), Copper (Cu), Iron (Fe), and Zinc (Zn). The results of the analysis strongly suggested that a functioning benthic invertebrate community would not be able to survive in this creek under current conditions.

Mainstem Mineral Creek: The chemical conditions in the surface water of mainstem Mineral Creek were less severe than in mainstem Cement Creek for benthic invertebrates. However, low pH and high levels of dissolved Al during the pre-runoff period suggested that the benthic invertebrate community may experience high stress in the winter, but could possibly recover during the rest of the year. The results suggested that the benthic invertebrate community in mainstem Mineral Creek would likely experience high stress under current conditions.

Animas River at and below Silverton: The metal concentrations (particularly Cd, Cu, Lead (Pb), Manganese (Mn), and Zn) measured in the substrate of the Animas River at and below Silverton were expected to be highly toxic to benthic invertebrates. Sediment samples were only collected in May 2012. The SLERA assumed that seasonal variations in sediment COPEC levels would be relatively minor, such that the available metals data represented exposure conditions throughout the year. Only more sediment sampling in the Animas River at and below Silverton at other times of the year as part of a future BERA sampling effort can address seasonal variation in sediment contamination. The results suggested that the benthic invertebrate community in the Animas River at and below Silverton would likely experience high stress under current conditions.

ES.3 Risk conclusions for fish

Mainstem Cement Creek: The chemical conditions in mainstem Cement Creek were expected to be highly toxic to fish, particularly due to high levels of acidity and dissolved Al, but also due

to Cd, Cu, Fe, and Zn. The results of the analysis strongly suggested that a functioning fish community would not be able to survive in this creek under current conditions.

Mainstem Mineral Creek: The chemical conditions in mainstem Mineral Creek were less severe than in mainstem Cement Creek for fish. However, low pH and high levels of dissolved Al during the pre-runoff period suggested that fish may experience significant stress in the winter, but could possibly recover during the remainder of the year. The results suggested that the fish community in mainstem Mineral Creek would likely experience high stress under current conditions.

Animas River at and below Silverton: The chemical conditions in the Animas River at and below Silverton reflected input from the Animas River above Silverton (Cd and Zn) and more local input from mainstem Cement Creek and mainstem Mineral Creek (Al and pH, with lesser inputs of Fe and Cu). The results strongly suggested that the fish community in the Animas River at and below Silverton would experience high stress under current conditions.

ES.4 Risk conclusions for wildlife receptors

The levels of metals in surface water, sediment, and food items ingested by the four wildlife receptor species foraging in the Animas River at and below Silverton had the potential to cause significant population-level risks, based on the prevailing (but conservative) assumptions used in the SLERA. The major risk-driving COPECs consisted of Al, Cu, Pb, and Zn. The highest relative risk was found in the American Dipper feeding on aquatic insects (plus ingesting surface water and sediment), whereas the lowest relative risk was found in the belted kingfisher feeding on fish (plus ingesting surface water but not sediment).

1.0 GENERAL INTRODUCTION

1.1 Scope

This report presents a Screening-Level Ecological Risk Assessment (SLERA) for the aquatic habitats in the Animas River Mining District, located in San Juan County, CO. It is structured based on the SLERA Work Plan (WP) submitted to the U.S. Environmental Protection Agency (EPA) in July 2012 (TechLaw, 2012).

The SLERA identified Contaminants of Potential Ecological Concern (COPECs) for community-level and wildlife receptors associated with mainstem Cement Creek, mainstem Mineral Creek and the Animas River in the vicinity of Silverton. Those COPECs were further analyzed to determine if they represented a risk to the receptors in the three waterways. As such, this SLERA provides an initial and conservative assessment of risk, and determines if enough information is available to support decisions making. The risk managers and risk assessors will then jointly decide if the ecological risks are unacceptable based on the assessment described in this report. Note that this evaluation did not attempt to separate natural background contamination from past mining-related contamination, but instead assessed the risk from all sources combined.

The Animas River in the vicinity of Silverton was divided into two reaches for the purposes of this SLERA, as follows:

- The reference section is called "the Animas River above Silverton" and refers to the river up to its confluence with Cement Creek in Silverton. Data from the reference sampling location (A 68) were collected from the Animas River a few hundred feet upstream of the confluence with Cement Creek. This portion of the river was not called "background" since it is impacted by water from further upstream in the watershed that has come in contact with mineralized material via natural processes and past mining activities. It is understood that the chemical and biological conditions in the Animas River above Silverton represent an area of on-going concern. However, this SLERA focused specifically on the Animas River at and below Silverton (see next bullet).

- The impacted section investigated by the SLERA is called "the Animas River at and below Silverton" and refers to the river from its confluence with Cement Creek to an area about 0.5 miles below the confluence with Mineral Creek. This reach covers about 1.5 miles of the Animas River.

1.2 General screening ecological risk assessment approach

The following guidance and reference documents were used to prepare this SLERA:

- EPA. 1997. Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team, Edison, NJ.

- EPA. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F.

- EPA. 2001. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. EPA/540/F-01/014.

EPA (1997) provides the general framework for planning and conducting the investigation. The screening process (Tier 1) consists of two broad steps, as follows:

STEP 1: Screening-level problem formulation and ecological effects evaluation

- **Screening-level problem formulation**: The problem formulation includes stressor characterization, identifying ecological receptors of concern, selecting assessment endpoints and measures of effect, and developing a Site Conceptual Model (SCM).

- **Screening-level ecological effects evaluation and COPEC selection**: The effects evaluation quantifies the toxicity of site-related chemicals based on published screening benchmarks and uses that information to select COPECs for further evaluation in Step 2.

STEP 2: Screening-level exposure estimates and risk calculations

- **Screening-level exposure estimate**: The exposure estimate identifies the EPCs for each Exposure Unit (EU) used in the evaluation. The maximum concentrations of site-related metals were selected as the EPCs to which receptors can be exposed to in the affected aquatic habitats.

- **Screening-level risk calculation**: The risk calculations are based on HQs. A chemical-specific HQ is obtained by dividing the EPC by its applicable screening benchmark. A chemical is retained as a COPEC for further evaluation under the following conditions: (1) the HQ exceeds 1.0, or (2) no screening benchmark is available to calculate an HQ. An uncertainty analysis is included in the discussion to provide context to the screening-level risk characterization.

The SLERA was an initial conservative risk evaluation to identify risk drivers and exposure pathways of concern to community-level and wildlife receptors.

1.3 Goals and objectives

Benthic invertebrates and fish represent the valued ecological resources to be protected in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton. In addition, four groups of birds and mammals were also identified as ecological resources to be protected in the Animas River at and below Silverton. These community-level and wildlife receptors provide the basis to develop site goals and objectives, and to select assessment endpoints for the SLERA.

The ecological risk management goal for the site was defined as follows:

> *"Promote healthy communities of aquatic and wildlife receptors in the waterways affected by site-related contamination."*

Four ecological risk assessment objectives were identified to accomplish this goal:

- Identify the presence of site-related COPECs that may pose a threat to one or more of the receptors;
- Document the potential exposure to those receptors using the available analytical datasets;
- Develop risk estimates and discuss major uncertainties; and
- Provide data for risk managers to determine the potential for ecological risk and to have enough information to support the risk management decision-making process.

This report recognizes that mainstem Mineral Creek upstream of the confluence with South Fork Mineral Creek, and mainstem Cement Creek, may not have supported a viable fish or macroinvertebrate community before large-scale mining activities due to naturally-high levels of metals and low pH in their surface waters (Church *et al.*, 2007). These two waterways are nonetheless included in this SLERA in order to provide a conservative risk evaluation and help identify risk drivers and exposure pathways of concern. It is expected that evaluating these naturally-impaired waterways within a risk-based context will provide more information to support a scientific management decision point for evaluation among the stake holders before proceeding with a future BERA.

2.0 SCREENING-LEVEL PROBLEM FORMULATION

2.1 Data processing

2.1.1 Evaluation of qualified and coded data

All analytical data assigned qualifiers indicating that a compound was positively detected or presumptively present (e.g., data qualified as J, D, or EB) were retained as detected results in the database and used in the SLERA as reported.

All analytical data assigned qualifiers indicating that the analyte was not positively detected (i.e., U, UJ) were retained only as non-detected results in the database.

Finally, any analytical data considered of inadequate quality for use in the SLERA (i.e., data qualified as R) were omitted from the database.

2.1.2 Compiling a database for use in the SLERA

The final product of the data evaluation and summarization process was a comprehensive database for all the surface water and sediment analytical data collected between May 2009 and May 2012 in mainstem Cement Creek, mainstem Mineral Creek, the Animas River above Silverton, and the Animas River at and below Silverton.

Individual data sets were developed by compiling analytical results for each matrix of interest (i.e., surface water and sediment), analyte group (i.e., total metals, dissolved metals, and pH), EU (i.e., mainstem Cement Creek, mainstem Mineral Creek, and Animas River), and sampling locations within each EU, if applicable.

Appendix 1 provides the available data for pH, hardness, and total plus dissolved metals concentrations measured in mainstem Cement Creek, mainstem Mineral Creek, the Animas above Silverton, and the Animas River at and below Silverton between May 2009 and May 2012. **Appendix 2** provides the available data for total metals in bulk sediment samples collected from the Animas River above Silverton, and the Animas River at and below Silverton in May of 2012. The USGS has historically collected and evaluated sediment data from the Upper Animas River basin (e.g., see Chapter E19 in Church *et al.*, 2007). Those data, which were obtained over a decade ago, were excluded from the SLERA because they were not considered to represent current exposure conditions.

Table 2.1 summarizes the type of analytical data used in the SLERA by sampling location and sampling period (Note: Section 4.3 explains how surface water samples collected in

different months between May 2009 and May 2012 were combined into three periods for use in the exposure calculations).

2.1.3 Hardness-dependent metals

The toxicity to aquatic organisms of Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Manganese (Mn), Nickel (Ni), Silver (Ag), and Zinc (Zn) varies with surface water hardness (EPA, 2009; CDPHE, 2009). The surface water samples available for use in the SLERA were collected across seasons between May 2009 and May 2012. The hardness of those surface water samples also varied seasonally.

It would have been inaccurate for the SLERA to select COPECs, calculate EPCs, or quantify risk for the aquatic community-level receptors without also accounting for differences in surface water hardness between sampling locations and sampling times. This issue was of no concern to wildlife receptors which ingest surface water from the Animas River above Silverton, and the Animas River at and below Silverton, because their rate of metal uptake from drinking was independent from water hardness.

The SLERA used the following protocol to address surface water hardness for the aquatic community-level receptors exposed to the eight hardness-dependent metals:

- *COPEC selection*: The eight hardness-dependent benchmarks were adjusted to the lowest hardness measured in the surface water samples collected between May 2009 and May 2012 across the three waterways. Using the lowest surface water hardness measured over a three-year sampling period across the three waterways ensured that the hardness-adjusted benchmarks used to identify COPECs were as conservative as possible and did not miss any hardness-dependent metals as COPECs.

- *Refined screen*: All dissolved metal concentration data were turned into sample-specific HQs (see Section 3.5.1 for further details) by dividing each measured concentration by its hardness-adjusted surface water benchmark. Calculating hardness-adjusted HQs ensured that these values could be directly compared across sampling locations, EUs, and seasons.

2.1.4 Data summarization method

The analytical data for total metals (unfiltered samples), dissolved metals (filtered samples), and pH in mainstem Cement Creek, mainstem Mineral Creek, the Animas River above Silverton, and the Animas River at and below Silverton were summarized separately by waterway, as follows:

- frequency of detection (number of detected values over the number of samples analyzed),
- minimum detected value (with data qualifier),
- maximum detected value (with data qualifier), and
- sampling location of the maximum detected value.

The following procedures were applied to compile data for a metal in a given matrix to calculate the summary statistics used in the SLERA:

- Results assigned qualifiers indicating that an analyte was positively detected or presumptively present were retained as reported for use in the exposure calculations.
- Results assigned qualifiers indicating that an analyte was not positively detected (data flagged as "U" or "UJ") were retained at one half of their Detection Limit (DL).
- Any results considered of inadequate quality (i.e., data qualified as "R") were not used in the risk calculations.
- Analytical results for samples collected from the same location but during different sampling events were considered unique samples and were not combined.
- Analytical data from duplicate samples (i.e., samples collected at the same location and date) were averaged. These data were handled as follows:
    - If both samples had a detected value, the average concentration and the most conservative of the two data qualifiers was used as the maximum value (e.g., if one value had no flag and the second value was flagged as "J", then the average concentration was calculated and flagged as "J").
    - If one of the duplicates had a detected value and the other had an undetected value, then only the detected value and its associated flag (if available) was used as the maximum value. This approach was necessary because in some cases the undetected value was substantially higher than the detected value. Taking an average of these two numbers would artificially have inflated the maximum value.
    - If the values in both samples were non detect, then the highest of the two method detection limits was used, if necessary.

2.2 Problem formulation

Steps 1 and 2 of the ERA process identify conservative site-related risks to the environment and determine if further assessment is warranted. The goal of this effort was to provide an initial assessment of potential ecological risks for use in risk management decision making.

2.2.1 Environmental setting and contaminants at the site

2.2.1.1 Brief site description and history

The information summarized in this subsection was obtained from Church *et al.* (2007) and EPA (2012).

The mining district is located in the northernmost headwaters of the Animas River watershed in San Juan County, CO. It covers the drainage basin of the Animas River at and upstream of the town of Silverton, CO, its two main tributaries (i.e., Cement Creek and Mineral Creek), and a short reach of the Animas River downstream from the confluence with Mineral Creek (see **Figure 2.1**). Elevations in the watershed range between about 9,000 feet (ft) and 13,500 ft.

The discovery of gold and silver brought miners to the area in the early 1870's. The discovery of silver in the base-metal ores was the major factor in establishing Silverton as a permanent settlement. Between 1870 and 1890, the richer ore deposits were discovered and mined. Not until 1890 was a serious attempt made to mine and concentrate the larger low-grade ore bodies in the area. Twelve concentration mills operated in the valley by 1900. All sent their products to the Kendrick and Gelder Smelter near the mouth of Cement Creek in Silverton.

Mining and milling operations slowed down around 1905, and mines were consolidated into fewer and larger operations with the facilities for milling large volumes of ore. After 1907, mining and milling continued in the basin whenever prices were favorable. Gladstone, located about eight miles upstream of Silverton on Cement Creek, is the site of an historic mining town developed in the 1880s in response to the onset of mining. The town was the central location and railroad terminus for milling and shipping mine ores from the surrounding valley. Gladstone declined in the 1920's and no remnants of it remain visible today.

The Sunnyside Mine was the only active year-round mine left in the county by the 1970's. This mine ceased production in 1991, and underwent extensive reclamation. The Gold King Mine's permit with the Division of Reclamation, Mining and Safety was revoked by the Colorado Mined Land Reclamation Board and the financial warranty bond was forfeited in 2005.

The Sunnyside Mine was accessed through the American Tunnel which has its portal in Gladstone. The American Tunnel drained up to 1,600 gallons per minute (gpm) of water prior to bulkhead installations. The Standard Metals Corporation constructed a lime feed and settling pond-type treatment facility in Gladstone in 1979. Water discharging from the American Tunnel was treated as required by the water discharge permit. The facility operations and mine ownership was later transferred to the Sunnyside Gold Corporation (SGC). SGC installed 11 bulkheads within the Sunnyside Mine as part of a court-ordered consent decree to terminate their discharge permit. These bulkheads greatly reduced the volume of discharge from the American Tunnel. Currently, between 70 and 100 gpm continue to discharge from the American Tunnel, presumably from near-surface groundwater. SGC met all the terms of the consent degree in 2002.

The treatment facility, operations, and permit were transferred to the Gold King Mines Corporation in January 2003. The settling ponds were deeded to the San Juan Corporation by SGC prior to the lease between the Gold King Mines and San Juan Corporations. The treatment facility continued to treat American Tunnel discharge and the Gold King discharge until September 2004. The San Juan Corporation required SGC to reclaim the four settling ponds (completed in 2005) when the San Juan Corporation and the SGC lease were terminated. The Gold King Mines Corporation was subsequently evicted and the balance of the Gold King Mines Corporation land was acquired by the San Juan Corporation as the lien holder. The American Tunnel portal reclamation and the removal of some out-buildings were completed in 2006. The Bureau of Land Management manages land associated with the American Tunnel portal and its immediate vicinity, whereas the San Juan Corporation owns most of the surrounding land.

Many abandoned mines exist within a two-mile radius of Gladstone. They include: the Upper Gold King 7 Level, American Tunnel, Grand Mogul, Mogul, and Red and Bonita, Eveline, Henrietta, Joe and John, and Lark mines. Some of these mines have acid mine drainages with produce flows of between 30 and 300 gpm that directly or indirectly enter Cement Creek and eventually reach the Animas River. The Animas River Stakeholder Group, the Bureau of Land Management, private stakeholders, and the Division of Reclamation, Mining and Safety have completed remediation projects at the Eveline, Henrietta, Joe and John, and Lark mines.

Existing and historical data suggest that conditions have changed recently at several locations where site-impacted waters enter upper Cement Creek. For example, flows have increased at the Red and Bonita mine and the upper Gold King 7 Level. The data also show higher levels of Aluminum (Al), Cd, Cu, Mn and Zn in Cement Creek and downstream in the Animas River at and below Silverton between 2005 and 2007. These increases coincide with the end of active water treatment in Gladstone in 2005 and the installation of bulkheads at the American Tunnel.

The headwaters and tributaries of Cement Creek, Mineral Creek, and the Animas River originate in treeless alpine regions. With a few exceptions, the streams follow high-gradient, narrow glaciated valleys. The vegetation along those valleys is rather sparse in the presence of extensive areas of exposed rock and talus (i.e., a sloping mass of rock debris at the base of a cliff).

Past surveys of fish and benthic invertebrate communities showed that the headwaters of the Animas River above Silverton, the main stems of Cement and Mineral Creeks, and several smaller tributaries support little or no aquatic life due to the presence of site-related contamination. On the other hand, South Fork Mineral Creek and several tributaries of the upper Animas River drain basins that provide substantial acid-neutralizing capacity and support viable trout populations. The Animas River between Maggie Gulch (located about eight river miles upstream from Silverton) and the mouth of Cement Creek in Silverton supports brook trout and a robust invertebrate community (see Chapters D and E18 in Church *et al.*, 2007), which suggests substantial improvements in surface water quality since the 1970's. Note, however, that sections of the Animas River further upstream from Maggie Gulch are still severely impacted by past mining activities. The stream biota in the Animas River downstream from Silverton are also degraded due to input from Cement and Mineral Creeks (see Chapters A, D, E18, and E19 in Church *et al.*, 2007).

2.2.1.2 Past sampling of environmental media

EPA and others have collected numerous samples from Cement Creek, Mineral Creek, and the Animas River in the vicinity of Silverton for chemical analyses over the last 20 years. However, the SLERA only used the analytical data from surface water samples collected between May 2009 and May 2012, plus a few sediment samples collected from the Animas River above Silverton, and the Animas River at and below Silverton in May 2012. This approach ensured that the aquatic exposures reflected "current" conditions.

Recent sediment samples were not available from mainstem Cement Creek and mainstem Mineral Creek. Hence, the potential exposure of benthic invertebrates to metals present in the substrate of those two waterways could not be assessed based on sediment data. Instead, the SLERA quantified benthic invertebrate exposure to metals using surface water data, on the assumption that mine-related exposures by many of the benthic invertebrate species were likely to have a substantial surface water component.

2.2.1.3 Suspected contaminants

Acid conditions result from the interaction of sulfide minerals, water, and oxygen, which yields highly-acidified drainage water. This water dissolves metals present in bedrock, veins, ore, tailings, and waste rock, including Al, Cd, Cu, and Zn. These dissolved metals can be transported overland or via groundwater to small tributaries that connect to Cement Creek and Mineral Creek, and eventually to the Animas River at and below Silverton.

The higher pH of the surface water flowing in the Animas River at and below Silverton could cause some of the dissolved metals to precipitate out of solution and become integrated into the substrate. Metals are also carried in particulate form (e.g., fine tailings) by the water current and deposited in lower-energy areas of the affected waterways. Previous investigations showed that numerous metals in surface water samples from the three targeted waterways exceeded applicable water quality standards (see Chapter D in Church *et al.*, 2007).

2.2.2 Ecological resources potentially at risk

The ecological resources of concern to this SLERA were (a) the aquatic community-level receptors (i.e., fish and benthic invertebrates) directly exposed to metals in surface water from mainstem Cement Creek and mainstem Mineral Creek, (b) fish exposed to metals in surface water from the Animas River at and below Silverton, (c) benthic invertebrates exposed to metals in sediment from the Animas River at and below Silverton, and (d) wildlife receptors exposed to metals in surface water and sediment from the Animas River at and below Silverton, and in food items obtained from the Animas River at and below Silverton.

A list of Threatened and Endangered (T&E) species was obtained from the Colorado Wildlife Heritage Foundation and from the Colorado Parks and Wildlife species of concern list for San Juan County, Colorado (updated December 2011). Two mammals identified on the lists were the lynx (*Lynx Canadensis)* and the wolverine (*Gulo gulo).* The lynx is listed as federally threatened and state endangered while the wolverine is listed as state endangered. The boreal toad (*Bufo boreas boreas)* is listed as state endangered. For birds, the southwestern willow flycatcher (*Empidonax trailii extimus)* is listed as federally endangered and state endangered. This T&E species, if present in the riparian habitat along the Animas River at and below Silverton, was assumed to have the potential for exposure to site-derived contamination.

The southwestern willow flycatcher is a small passerine bird which breeds in dense riparian habitats along rivers, streams, or wetlands and feeds on insects. The riparian vegetation can be dominated by dense growths of willows (*Salix* sp.), seepwillow (*Baccharis* sp.), or other shrubs and medium-sized trees. An overstory of cottonwood (*Populus* sp.), tamarisk (*Tamarix* sp.), or other large trees may be present but this is not necessary. In some areas, the flycatcher

nests in habitats dominated by tamarisk and Russian olive (*Eleagnus angustifolia*). A key characteristic of breeding habitat appears to be the presence of dense vegetation, usually throughout all vegetation layers present.

Almost all southwestern willow flycatcher breeding habitats are less than 20 yards from water. At some sites, surface water is present early in the nesting season, but gradually dries up as the season progresses. Ultimately, the breeding site must have a water table high enough to support riparian vegetation.

It is not known if the riparian vegetation along the shoreline of the Animas River at and below Silverton represents desirable breeding habitat for the southwestern willow flycatcher. However, the SLERA assumed that the species might be present based on its listing in San Juan County and the existence of riparian habitat.

2.3 Preliminary fate and effects evaluation

A preliminary evaluation of the fate and transport of site-related contamination helped to identify potentially complete exposure pathways. A brief summary of the fate and effects information, together with data on the ecotoxicity of site-related contamination to the community-level and wildlife receptors, are discussed below.

2.3.1 Fate and transport

The information provided by Church *et al.* (2007) was reviewed to determine which fate and transport mechanisms might result in complete exposure pathways to aquatic community-level receptors in the three targeted waterways or to wildlife receptors feeding on aquatic food items in the Animas River at and below Silverton (Note: The SLERA assumed that wildlife receptors foraged only in the Animas River at and below Silverton because fish and aquatic invertebrates appear to be largely absent from mainstem Cement and Mineral Creeks under current conditions). The goal was to identify the major elements of a complete exposure pathway, which consist of the following components.

- Source(s) of contamination,
- Release and transport mechanisms,
- Contact points and exposure media,
- Routes of entry, and
- Key receptors.

Each of these components is discussed below.

- **Sources of contamination**

The major sources of contamination relating to past mining in the watersheds of Cement Creek, Mineral Creek, and the Animas River above Silverton consist of one or more of the following activities: tunneling to reach the ore veins and to drain groundwater out of mine workings, disposal of waste/overburden rock, and disposal of mine tailings on land and in waterways.

In addition, natural sources of regional contamination consist of groundwater which has come in contact with undisturbed mineralized materials.

- **Release and transport mechanisms**

Some of the rocks are enriched with sulfide minerals (e.g., pyrrhotite, pyrite and chalcopyrite). These minerals react with water and atmospheric oxygen over time. The oxidation process generates sulfuric acid, which in turn causes metals to dissolve out of host rock, vein rock, waste rock, and tailings. This highly acidic and metal-rich effluent is toxic to aquatic receptors due to its low pH and high dissolved metal content.

The following release and transport mechanisms may potentially have affected the concentration and spatial distribution of metals in the affected waterways.

- Dissolution and leaching of metals from mine waste, host rock, or vein rock into groundwater,
- Migration of metals in groundwater to sediment and surface water in adjacent surface water bodies, and its attenuation by dilution/dispersion and sorption,
- Transport of metals adsorbed to soil/tailings particles via terrestrial runoff,
- Transport of metals in surface water runoff, and
- Trophic transfer of metals incorporated in aquatic food chains.

The potential release of site-related contamination and their transport from the sources to points of contact with aquatic receptors in the three targeted waterways depends on their chemical speciation, concentration, presence of nearby surface water bodies, and the extent and duration of precipitation or snowmelt events. Surface water runoff and groundwater infiltration are particularly important transport mechanisms for soluble species of metals.

- **Contact point and exposure media**

Mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton were the contact points evaluated in the SLERA. The exposure media were as follows:

- Surface water (all three EUs).
- Sediment (only in the Animas River at and below Silverton).
- Prey items for wildlife receptors (only in the Animas River at and below Silverton).

- **Routes of entry**

The main routes of entry evaluated in the SLERA for aquatic community-level receptors, and wildlife receptors feeding on aquatic prey, were as follows:

- Direct contact with surface water and sediment via dermal and/or gill absorption (aquatic community-level receptors).
- Surface water ingestion (wildlife receptors).
- Incidental sediment ingestion (wildlife receptors, except for the belted kingfisher).
- Ingestion of contaminated food items (wildlife receptors).

The SLERA evaluated the complete exposure pathways for direct contact with surface water and sediment by aquatic community-level receptors, and ingestion of surface water, sediment, and aquatic food items by wildlife receptors feeding in the Animas River at and below Silverton. Exposure to metals via inhalation was omitted because it was considered to be minor for wildlife receptors feeding on aquatic food items.

- **Key receptors**

  - **Aquatic receptors**

The SLERA assumed that benthic invertebrates and fish can live above, on, and/or within the substrate in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton.

  - **Wildlife receptors feeding on aquatic food items**

The SLERA assumed that the following types of wildlife receptors could become exposed to site-related contamination while feeding in the Animas River at and below Silverton: (a) insectivorous birds, (b) omnivorous birds, (c) piscivorous birds, and (d) herbivorous mammals.

- **Ecotoxicity**

Acidity and metals are the two major chemical stressors in the aquatic habitats potentially affected by site-related contamination.

Acidity/low pH

Sulfuric acid is released when water and oxygen interact with sulfide-rich materials. Low pH is toxic to aquatic receptors. Sensitive species of fish and aquatic invertebrates experience increased mortality at a pH around 6.0. Brook trout populations disappear from streams when pH drops to the low 5.0's for an extended period of time.

Metals

High acidity solubilizes metals, resulting in metals-enriched surface water runoff. Dissolved metals are of the highest concern because, unlike metals associated with the particulate fraction, they are bioavailable to exert direct toxicity to aquatic receptors.

Both acidity and dissolved metals affect osmoregulation in aquatic organisms by changing the integrity of the cell junctions in the gill tissues. The cell junctions become "leaky" with increasing levels of H^+ (protons) or metals, thereby allowing blood electrolytes to diffuse out of the gill tissue, and water to diffuse into the bloodstream. Death results when blood electrolyte levels drop below a critical physiological threshold, which varies from species to species.

2.3.2 Ecosystems potentially at risk

The potentially impacted aquatic habitats evaluated in the SLERA consisted of mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton.

2.3.3 Complete exposure pathways

Routes of exposure are the means by which COPECs can be transferred from a contaminated medium to ecological receptors. The principal receptors and routes of exposure evaluated in the SLERA were as follows:

- Benthic invertebrates: direct contact with sediment (Animas River at and below Silverton) or surface water (mainstem Cement Creek and mainstem Mineral Creek).
- Fish: direct contact with surface water in all three waterways.
- Insectivorous birds: ingestion of surface water, sediment, and aquatic insects from the Animas River at and below Silverton.

- Omnivorous birds: ingestion of surface water, sediment, benthic invertebrates, and aquatic plants from the Animas River at and below Silverton.

- Piscivorous birds: ingestion of surface water and fish from the Animas River at and below Silverton (Note: The belted kingfisher, which is the modeled piscivorous bird, is assumed not to ingest sediment because it captures small fish from within the water column and swallows them whole while perched on tree branches).

- Herbivorous mammals: ingestion of surface water, sediment, and aquatic plants from the Animas River at and below Silverton.

2.4 Target receptors

2.4.1 Introduction

Endpoints were selected to help quantify the risks to representative receptors that may be exposed to metals and low pH associated with current mine releases.

Assessment endpoints represent explicit expressions of the key ecological resources to be protected from harm. They generally reflect sensitive populations, communities, or trophic guilds. Four criteria used for selecting the proposed assessment endpoints for the SLERA are listed below. The ecological resource should:

- have relevance,
- be susceptible to the stressors of concern,
- have biological, social, and/or economic value, and
- be relevant to the risk management goals for the site.

By considering these selection criteria, risks identified to one or more of the assessment endpoints will help inform the risk management decision process at the site.

Measures of effect represent measurable ecological characteristics, quantified through laboratory or field experimentation, which can be related back to the valued ecological resources chosen as the assessment endpoints. Measures of effect were required because it is often not possible to directly quantify risk to an assessment endpoint. The measures of effect represented the same exposure pathway(s) and mechanisms of toxicity as the assessment endpoints in order to be relevant and useful.

Risk questions establish a link between assessment endpoints and their predicted responses when exposed to COPECs. The risk questions should provide a basis to develop the study design and evaluate the results of the site investigation in the analysis phase and during risk characterization (EPA, 1997).

2.4.2 Representative species or communities

It is neither practical nor possible to evaluate the potential for ecological risk to all of the individual parts of the local aquatic ecosystem potentially affected by site-related contamination. Instead, key components were identified to select those species or groups most likely to experience exposure to the stressors.

2.4.2.1 Community-level receptors

Benthic invertebrates

Benthic invertebrates form an integral link in all aquatic ecosystems. They play a key role in nutrient and energy transfers within those systems. They also process and assimilate organic material, feed on other invertebrates, and are themselves consumed by fish, birds, and mammals.

Metals with the potential to bioaccumulate can be transferred from the sediment or surface water into the benthic invertebrate community and up the food chain, thereby harming higher-level receptors. Significant alterations in invertebrate communities could also impact the energy cycling at the base of the aquatic food chain.

The substrate in the three waterways of interest to the SLERA should be able to support a diverse benthic invertebrate community. Key invertebrates include amphipods and the aquatic life stages of numerous insect species (e.g., mayflies, stoneflies, caddisflies, dragonflies, etc.).

Note that it is considered possible that mainstem Mineral Creek upstream of the confluence with South Fork Mineral Creek, and mainstem Cement Creek, may not have supported a macroinvertebrate community before large-scale mining activities started in the 19^{th} century (Church *et al*., 2007) due to naturally-high levels of metals and low pH. However, the SLERA conservatively evaluated the potential ecological risk to a hypothetical benthic invertebrate community in these waterways in order to assess the current conditions and assist win identifying risk drivers. The outcome of this evaluation should be interpreted in a broader context which considers naturally-altered surface water and substrate conditions.

Fish

The three waterways should be able to support a healthy fish community, consisting of cold-water stream species, such as trout and sculpin. The aquatic environment should provide such a community with a diverse food base, suitable feeding and spawning areas, refuges for juvenile fish, and other essential environmental services.

The presence of metals in the surface water and sediment can impair the local fish community in two general ways: (1) mortality of sensitive early life stages exposed to dissolved metals in the water column or pore water, or (2) high metal concentrations in aquatic biota via food chain uptake, which could affect reproduction and the long-term survival of the exposed fish.

As with the benthic invertebrate community, it is considered possible that mainstem Mineral Creek upstream of the confluence with South Fork Mineral Creek, and mainstem Cement Creek, may not have supported fish before large-scale mining activities started in the 19th century (Church *et al.*, 2007). However, the SLERA conservatively evaluated the potential ecological risk to a hypothetical fish community in these waterways in order to assess the current conditions. The outcome of this evaluation should be interpreted in a broader context which considers naturally-altered surface water conditions.

2.4.2.2 Wildlife receptors

It is not known what kinds of wildlife receptors are commonly associated with the Animas River at and below Silverton. The Durango Bird Club performed a three-hour bird count at wetlands on the Animas River near the town of Durango on September 9, 2012. These wetlands are located about 50 miles downstream from Silverton and may not represent habitat commonly found on the Animas River at and below Silverton. Regardless, the list was used as a starting point to help identify plausible wildlife receptors for use in aquatic food chain modeling.

The table below lists the bird species observed at the Durango wetlands that may obtain some or all of their food from an aquatic environment (i.e., the Animas River) below Silverton:

- great blue heron (*Ardea Herodias*): piscivore
- Canada goose (*Branta Canadensis*): herbivore
- Mallard (*Anas platyrhynchos*): aquatic and terrestrial herbivore and invertivore
- Common merganser (*Mergus merganser*): piscivore
- Spotted sandpiper (*Actitis macularius*): benthivore
- Northern rough-winged swallow (*Stelgidopteryx serripennis*): aquatic insectivore
- Barn swallow (*Hirundo rustica*): aquatic insectivore

Four kinds of bird and mammal species were assessed using exposure modeling to calculate metal-specific Estimated Daily Doses (EDDs) from drinking surface water, ingesting sediment, and feeding on aquatic food items from the Animas River at and below Silverton. The SLERA did not derive EDDs for wildlife receptors in mainstem Cement Creek and mainstem Mineral Creek because these two waterways do not support viable aquatic invertebrate and fish communities under current conditions. The SLERA evaluated the following target wildlife receptors.

- Insectivorous birds: represented by the American dipper (*Cinclus mexicanus*)

The American dipper is a small passerine bird which forages on the bottom of fast-moving rocky streams in mountainous regions of the western US. It dives to the bottom of the stream where it seeks out mainly aquatic insects and their larvae, but also small crustaceans (e.g., juvenile crayfish) or tiny fish and tadpoles. This species was selected for use in food chain modeling to represent birds which feed on aquatic insects and benthic invertebrates, such as the spotted sandpiper and the two swallow species observed in the Animas River wetlands above Durango. It also serves as a surrogate for the southwestern willow flycatcher, a T&E species of passerine insectivore listed for San Juan County, CO, which may or may not be present in the riparian habitat of the Animas River at and below Silverton.

- Omnivorous birds: represented by the mallard (*Anas platyrhynchos*)

The mallard is a medium-sized dabbling duck with a flexible diet consisting of aquatic and terrestrial plants (including leaves, stems, seeds, roots and tubers), but also aquatic invertebrates (e.g., crustaceans and aquatic insects), and terrestrial invertebrates (e.g., worms, snails, slugs, beetles). This species was selected for use in food chain modeling to represent avian herbivores who also have the ability to switch to a invertivorous diet, such as the mallard and (to a lesser degree) the Canada Goose observed in the Animas River wetlands above Durango.

- Piscivorous birds: represented by the belted kingfisher (*Ceryle alcyon*)

The belted kingfisher is a piscivore which feeds mostly on fish that swim near the surface or in shallow areas of ponds, lakes, rivers, and streams. The bird catches fish by diving head-first into the water in flight or jumping from a perch along the shoreline. This species was selected for use in food chain modeling to represent fish-eating birds, such as the great blue heron or common merganser observed in the Animas River wetlands above Durango.

- Herbivorous mammals: represented by the muskrat (*Ondatra zibethicus*)

The muskrat is an aquatic rodent which feeds primarily on aquatic plants such as marsh grasses, sedges, cattails, bulrushes and green algae. The herbivorous diet can be complemented by small amounts of crayfish, mollusks, fish, frogs, turtles, and young birds. This species was selected for use in food chain modeling to represent semi-aquatic herbivorous mammals such as the muskrat and the beaver which may be present in the Animas River at and below Silverton.

2.4.3 Selecting assessment endpoints and measures of effect

2.4.3.1 Assessment endpoints and risk questions

The following assessment endpoints were used in the SLERA to evaluate the potential risks to the aquatic receptors, and wildlife receptors feeding on aquatic food items from the Animas River at and below Silverton. A risk question was appended to each assessment endpoint.

The SLERA assumed that by evaluating and protecting the assessment endpoints, all of the aquatic habitats, and the wildlife receptors feeding on them, were protected as well.

- **Maintain a stable and healthy benthic invertebrate community**: *Are the metal levels in sediment (Animas River at and below Silverton only) and surface water (mainstem Cement Creek and mainstem Mineral Creek only) high enough to impair the benthic invertebrates in these three waterways?*

- **Maintain a stable and healthy fish community**: *Are the metal levels in surface water high enough to impair the fish in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton?*

- **Maintain stable and healthy insectivorous bird populations**: *Are the metal levels in surface water, sediment, and aquatic invertebrates high enough to impair insectivorous birds foraging in the Animas River at and below Silverton?*

- **Maintain stable and healthy omnivorous bird populations**: *Are the metal levels in surface water, sediment, aquatic invertebrates, and aquatic plants high enough to impair omnivorous birds foraging in the Animas River at and below Silverton?*

- **Maintain stable and healthy piscivorous bird populations**: *Are the metal levels in surface water and fish high enough to impair piscivorous birds foraging in the Animas River at and below Silverton?*

- **Maintain stable and healthy herbivorous mammal populations**: *Are the metal levels*

in surface water, sediment, and aquatic plants high enough to impair herbivorous mammals foraging in the Animas River at and below Silverton?

2.4.3.2 Measures of effect

Assessment endpoint #1:

Maintain a stable and healthy benthic invertebrate community: *Are the metal levels in sediment (Animas River at and below Silverton only) or surface water (mainstem Cement Creek and mainstem Mineral Creek only) high enough to impair the benthic invertebrates in these three waterways?*

The SLERA used one measure of effect to assess the potential impacts of metals to this receptor group, as follows:

1.A Compare the maximum total metal levels measured in sediment samples (Animas River at and below Silverton) or dissolved metals measured in surface water samples (mainstem Cement Creek and mainstem Mineral Creek) to screening-level sediment and surface water benchmarks, respectively.

Assessment endpoint #2:

Maintain a stable and healthy fish community: *Are the metal levels in surface water high enough to impair the fish in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton?*

The SLERA used one measure of effect to assess the potential impacts of metals to this receptor group, as follows:

2.A Compare the maximum dissolved metal levels measured in surface water samples to screening-level surface water benchmarks.

Assessment endpoint #3:

Maintain stable and healthy insectivorous bird populations: *Are the metal levels in surface water, sediment, and aquatic invertebrates high enough to impair insectivorous birds foraging in the Animas River at and below Silverton?*

The SLERA used one measure of effect to assess the potential impacts of metals ingested by this receptor group, as follows:

3.A Use the maximum total metal concentrations in surface water to estimate metal residues in aquatic invertebrates; use food chain modeling to calculate metal-specific maximum EDDs from ingesting surface water, sediment, and aquatic invertebrates, and compare these EDDs to avian no-effect TRVs.

<u>Assessment endpoint #4</u>:

Maintain stable and healthy omnivorous bird populations: *Are the metal levels in surface water, sediment, aquatic invertebrates, and aquatic plants high enough to impair omnivorous birds foraging in the Animas River at and below Silverton?*

The SLERA used one measure of effect to assess the potential impacts of metals ingested by this receptor group, as follows:

4.A Use the maximum total metal concentrations in surface water to estimate the metal residue levels in aquatic invertebrates and aquatic plants; use food chain modeling to calculate metal-specific maximum EDDs from ingesting surface water, sediment, and food, and compare these EDDs to avian no-effect TRVs.

<u>Assessment endpoint #5</u>:

Maintain stable and healthy piscivorous bird populations: *Are the metal levels in surface water and fish high enough to impair piscivorous birds foraging in the Animas River at and below Silverton?*

The SLERA used one measurement endpoint to assess the potential impacts of metals ingested by this receptor group:

5.A Use the maximum total metal concentrations in surface water to estimate the metal residue levels in fish; use food chain modeling to calculate metal-specific maximum EDDs from ingesting surface water and fish, and compare these EDDs to no-effect avian TRVs.

<u>Assessment endpoint #6</u>:

Maintain stable and healthy herbivorous mammal populations: *Are the metal levels in surface water, sediment, and aquatic plants high enough to impair herbivorous mammals*

foraging in the Animas River at and below Silverton?

The SLERA used one measurement endpoint to assess the potential impacts of metals ingested by this receptor group:

6.A Use the maximum total metal concentrations in surface water to estimate the metal residue levels in aquatic plants; use food chain modeling to calculate metal-specific maximum EDDs from ingesting surface water, sediment, and aquatic plants, and compare these EDDs to no-effect mammalian TRVs.

2.6 Site conceptual model

The SCM provides the foundation of a problem formulation. The SCM was developed based on knowledge of natural and man-made sources, contaminants, complete exposure pathways, and ecological receptors. The model shows how metals move from the contaminant sources through the exposure media to the receptors. **Figure 2.2** presents the SCM for the SLERA.

The primary sources of contamination to the local water ways consists of water which has come in contact with local rock, either naturally or as a result of mining activities, such as through the creation of adits. Sulfuric acid is released when water and oxygen interact with the sulfide-rich mine wastes, host rock, or vein rock. This acid dissolves metals which enter the waterways as surface runoff, or via the groundwater (e.g., seeps; adits). Fine tailings material may also be present in the substrate of the waterways. This material can serve as a secondary source of metals to the benthic invertebrate community.

The surface waters in mainstem Cement Creek and mainstem Mineral Creeks carry high loads of total and dissolved metals, and high acidity, into the Animas River at and below Silverton, even though substantial dilutions take place at that point. The benthic invertebrates and fish in the affected waterways become exposed to mine-derived and naturally-high levels of metals mainly by direct contact with surface water and sediment, whereas the wildlife receptors foraging in the Animas River at and below Silverton become exposed by ingesting surface water and sediment, and consuming fish, aquatic invertebrates, or plants. The current metal levels are high enough, and pH levels low enough, to cause mainstem Cement Creek and mainstem Mineral Creek to be essentially devoid of aquatic life, and to potentially affect aquatic life in the Animas River at and below Silverton.

3.0 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION AND COPEC SELECTION

3.1 Matrices of concern

As mentioned earlier, the SLERA used only the analytical data from surface water samples collected between May 2009 and May 2012 from the three targeted waterways, plus sediment samples collected from the Animas River at and below Silverton in May 2012, to help assess current exposure conditions to aquatic community-level receptors and wildlife receptors.

3.2 Total metals versus dissolved metals

The surface water metal data consisted of both total metals (i.e., unfiltered) and dissolved metals (i.e., filtered).

- Exposures to the aquatic community-level receptors in mainstem Cement Creek, mainstem Mineral Creek and the Animas River at and below Silverton were quantified using only dissolved metals because these data represented the fraction which is bioavailable, and hence toxic, to invertebrates and fish.

- The wildlife exposures associated with ingesting surface water from the Animas River at and below Silverton was quantified using total metals concentrations, which are typically higher than the dissolved metals concentrations.

This dual approach ensured that the exposure of each receptor group to surface water was properly accounted for.

3.3 Screening benchmarks

3.3.1 Surface water benchmarks

The dissolved metals concentrations measured in surface water samples collected from the three waterways were compared to surface water screening benchmarks to select COPECs for the aquatic community-level receptors. The Colorado State Water Quality Criteria (WQC) were the primary source of surface water benchmarks used in the evaluation.

The metal concentrations were compared to the chronic WQC (referred to as the Criteria Continuous Concentration [CCC]). The WQC were mostly the Class II cold water values developed by the Colorado Department of Public Health and the Environment (CDPHE, 2009). These benchmarks are based on dissolved metal concentrations, except for aluminum, iron, and

mercury, which are based on total-recoverable metal (CDPHE, 2009). The WQC for Ag, Cd, Cr, Cu, Pb, Ni, and Zn (Note: CDPHE developed a hardness equation for manganese, which was also used in the SLERA) were adjusted to the sample-specific hardness measured at each of the sample locations (see **Table 3.1** for equations) in order to calculate hardness-specific HQs.

National Recommended Water Quality Criteria (NRWQC) criteria (EPA, 2009), or chronic toxicity thresholds summarized by Buchman (2008) were used when Colorado State WQC were not available.

Table 3.1 summarizes the screening-level surface water benchmarks and equations used to select the surface water COPECs for aquatic community-level receptors and for use in the subsequent risk evaluation.

3.3.2 Sediment benchmarks

The metal concentrations measured in bulk sediment samples collected from the Animas River at and below Silverton in May of 2012 were compared to Threshold Effect Concentrations (TECs), which consisted of the Threshold Effect Level (TEL), the TEL for *Hyalella azteca* in 28-day tests (TEL-HA28), and the Effect Range-Low (ER-L). These screening benchmarks, which represent no observed adverse effect levels, are referred to in the text as no effect sediment benchmarks.

The following hierarchy was used to obtain the screening-level sediment benchmarks:

- MacDonald *et al.* (2000); consensus-based TECs,
- Ingersoll *et al.* (1996); TELs,
- Long *et al.* (1995); ER-Ls.

Table 3.1 summarizes the screening-level sediment benchmarks used to select the sediment COPECs for aquatic community-level receptors and for use in the subsequent risk evaluation. The shaded values will be used for that purpose.

3.4 TRVs for wildlife receptors

The following hierarchy was used to obtain the mammalian and avian TRVs for comparison to the EDDs in the wildlife risk characterization:

- EPA Eco SSLs (http://www.epa.gov/ecotox/ecossl/).

- Sample *et al.*, 1996, Toxicological Benchmarks for Wildlife: 1996 Revision, ES/ER/TM-86/R3, http://www.esd.ornl.gov/programs/ecorisk/documents/tm86r3.pdf (values represent the test species).

- EPA, 1999, Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities Peer Review Draft. November 1999., (http://www.epa.gov/osw/hazard/tsd/td/combust/ecorisk.htm)

These screening toxicity values, which represent no observed adverse effect levels, are referred to in the text as no effect TRVs. **Tables 3.2 and 3.3** present the no effect TRVs for mammals and birds, respectively.

3.5 COPEC selection process

The surface water and sediment COPECs are presented in the next subsections. Calcium, magnesium, potassium, and sodium were automatically eliminated as COPECs for aquatic community receptors and wildlife receptors because these four compounds represent essential physiological electrolytes that are not expected to cause toxicity at prevailing concentrations (EPA, 2001). The attachment below summarizes their concentrations as measured in the surface water samples collected from the three waterways between May 2009 and May 2012.

Sample Location	Calcium (mg/L)			Magnesium (mg/L)			Potassium (mg/L)			Sodium (mg/L)		
	average	min	max	average	min	max	average	min	max	average	min	max
Animas River												
A68 (reference)	43.8	17.4	73.9	2.8	1.3	4.1	NA	0.46	0.46	2.1	0.91	3.4
A72	64.8	15.9	127	4.6	1.4	8.5	NA	0.47	1.4	3.0	1.0	5.1
Mineral Creek												
M34	55.3	18.2	109	4.6	1.7	8.9	NA	0.38	1.1	3.2	1.3	6.0
Cement Creek												
CC48	133	28.6	209	8.0	2.4	11.9	NA	0.83	2.3	3.7	1.3	5.8

NA = not available due to too many values below the detection limit

3.5.1 Surface water COPECs for community-level receptors

The surface water COPEC selection process for aquatic community-level receptors evaluated the metals in two ways, depending on whether the toxicity of a metal was hardness-independent or hardness-dependent, as follows:

- Hardness-independent surface water toxicity

The toxicity of Al, beryllium (Be), Iron (Fe), and Selenium (Se) does not depend on hardness. COPEC selection for these four compounds consisted of comparing maximum dissolved metal concentrations measured in surface water samples (all three waterways combined) to conservative published surface water screening benchmarks.

- Hardness-dependent surface water toxicity

The toxicity of Cd, Cr, Cu, Pb, Mn, Ni, Ag, and Zn depend on surface water hardness. It would have been inaccurate to automatically select the highest concentration of each metal for use in COPEC selection because a lesser concentration could have been more toxic if the hardness was much lower.

Under those circumstances, the only reliable way to identify the most toxic concentration was to: (1) calculate hardness-adjusted HQs for each target metal in each surface water sample (Note: A hardness-adjusted HQ was obtained by dividing a metal concentration by its toxicity benchmark adjusted for the hardness of the water sample associated with that metal), (2) identify the highest HQ for a target metal in all of the surface water samples, and (3) select the metal concentration associated with that HQ as the concentration for use in COPEC selection.

This approach ensured that the metal concentration associated with the highest HQ was used in the COPEC-selection process. **Appendix 3** summarizes the hardness-adjusted HQs for the eight hardness-dependent metals.

Table 3.4 presents the surface water COPECs for the aquatic community-level receptors in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton. The following summarizes the results of the COPEC selection process:

- Arsenic (As), Cr, and Se were eliminated as COPECs because they were present in less than 5% of the samples and their maximum detection limits fell below the screening benchmarks.

- Ni was eliminated as a COPEC because its maximum concentration fell below the screening benchmark.

- pH was retained as a COPEC because its minimum concentration fell below the screening benchmark. Note that pH values are presented on a logarithmic scale and hence cannot be used to derive an HQ because the HQ calculations assume linearity.

- Al, Cd, Cu, Fe, Pb, Mn, Ag and Zn were retained as COPECs because their maximum concentrations exceeded the screening benchmarks.

- Be was not detected in any of the surface water samples, but was retained as a COPEC because its maximum detection limit exceeded the screening benchmark.

3.5.2 Sediment COPECs for community-level receptors

The issue of surface water hardness is not relevant when selecting bulk sediment COPECs. **Table 3.5** presents the sediment COPECs for the benthic community in the Animas River at and below Silverton. The following summarizes the results of the COPEC selection process:

- Al, Cr, Fe, Mercury (Hg) and Ni were eliminated as COPECs because their maximum concentrations fell below the screening benchmarks.

- As, Cd, Cu, Pb, Mn, Ag, and Zn were retained as COPECs because their maximum concentrations exceeded the screening benchmarks.

- Be and Se were also retained as COPECs because they lacked screening benchmarks.

3.5.3 COPECs for wildlife receptors

The approaches outlined above did not apply to the wildlife receptors assumed to forage in the Animas River at and below Silverton, because their exposures were not from direct contact with surface water or sediment, but from ingesting surface water, sediment, and aquatic food items. Therefore, a metal was automatically retained as a wildlife COPEC for evaluation in the food chain models if it was present in surface water or sediment above its detection limit. **Table 3.6** summarizes the COPECs used in the food chain models for the wildlife receptors.

The one exception to this rule pertained to Hg which was not analyzed in any of the surface water samples collected from the three target waterways between 2009 and 2012. Hg was excluded as a surface water analyte because it had not historically been identified as a sediment COPEC. As explained in Section 4 (Screening-level exposure estimates), the amount of metals in food items ingested by wildlife receptors feeding in the Animas River at and below Silverton was estimated by multiplying the maximum surface water concentrations by a conservative metal-specific bioconcentration factor. This approach precluded Hg because no surface water data were available for this compound.

4.0 SCREENING-LEVEL EXPOSURE ESTIMATES

4.1 Introduction

The exposure analysis for the SLERA consisted of the following two components: (a) quantify surface water and sediment exposures for the COPECs at the various sampling locations in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton, and (b) perform wildlife exposure modeling in the Animas River at and below Silverton.

The exposures for the four wildlife receptor species feeding in the Animas River at and below Silverton were assessed by obtaining the maximum surface water and sediment concentrations and performing food chain modeling to calculate maximum EDDs (mg/kg.bw/day).

4.2 Aquatic exposure units

The SLERA identified discrete aquatic EUs for summarizing the sediment and surface water analytical data to calculate maximum exposures for aquatic community-level and wildlife receptors. It would have been inappropriate to combine all of the analytical data across the three waterways, because each waterway represents a distinct exposure environment. The aquatic EUs were defined as follows (see also **Figure 2.1**):

- *Mainstem Cement Creek* was assessed as a single EU, but at three sampling locations:
  - Location CC21: across from the historic mining town of Gladstone (this location was sampled only once, in May 2012).
  - Location CC41: roughly halfway between Gladstone and Silverton (this location was sampled only once, in May 2012).
  - Location CC48: just upstream of the confluence with the Animas River in Silverton (this location was sampled numerous times between May 2009 and May 2012).
- *Mainstem Mineral Creek* was assessed as a single EU at one sampling location, as follows:
  - Location M34 is found in mainstem Mineral Creek just upstream of the confluence with the Animas River in Silverton (this location was sampled numerous times between May 2009 and May 2012).
- *The Animas River at and below Silverton* was assessed as a single EU at several sampling

locations, as follows:

- Location A72 is found about 0.5 miles downstream of the confluence with mainstem Mineral Creek (this location was sampled numerous times between May 2009 and May 2012).
- Up to 10 more sampling locations in the Animas River downstream of the confluence with mainstem Mineral Creek were sampled opportunistically for surface water and sediment in May 2012.

The chemistry measured at the locations in the Animas River at and below Silverton is a combination of the contaminant levels brought in by mainstem Cement Creek, mainstem Mineral Creek, and the Animas River above Silverton.

4.3 Seasonal effects

The surface water samples were collected throughout the year between May 2009 and May 2012 to investigate differences in metal loads across seasons. The surface water exposures for the aquatic community-level receptors and wildlife receptors were calculated at each of the sampling locations by season across years, as follows:

- Pre-runoff period: February, March, and April (2010 and 2011 data combined)
- Runoff period: May and June (2009, 2010, 2011, and 2012 data combined)
- Post-runoff period: July, August, September, October, and November (2009, 2010, and 2011 data combined)

This approach ensured that the surface water exposures reflected the seasonal differences that existed in metal concentrations in the three waterways over the 2009 to 2012 sampling period.

4.4 Exposure point concentrations

4.4.1 Surface water

COPEC-specific EPCs were developed for each of the sampling locations at each EU for surface water (all three water bodies) and sediment (Animas River at and below Silverton only).

The EPCs used in the SLERA consisted of the maximum value for each period (i.e., pre-runoff, runoff, and post runoff). The concentrations of the dissolved metals were also assessed

on a sample-by-sample basis. This included the eight hardness-dependent dissolved metals, which were evaluated by calculating HQs based on dividing the measured concentrations by their hardness-adjusted surface water benchmarks.

Table 4.1 summarizes the EPCs for the surface water COPECs. Note that the concentrations for metals with hardness-dependent toxicity do not necessarily represent the maximum values provided in **Appendix 1**, but instead represent the concentrations with the highest hardness-adjusted HQs as summarized in **Appendix 3**.

4.4.2 Sediment

COPEC-specific EPCs were developed for the Animas River at and below Silverton. The EPCs used in the SLERA consisted of the maximum concentrations measured in May 2012 (i.e., the runoff period). No other recent sediment samples were available for evaluation.

Table 4.2 summarizes the EPCs for the sediment COPECs. Note that these values are identical to the maximum sediment concentrations presented in **Table 3.5**, except for Hg which was excluded from food chain modeling due to a lack of surface water analytical data.

4.4.3 Wildlife receptors

Wildlife exposures were evaluated only for the Animas River at and below Silverton. **Table 4.3** presents the surface water and sediment EPCs used in the food chain models. These values are identical to the maximum surface water and sediment concentrations presented in **Table 3.6**.

4.5 Wildlife food chain modeling

Section 2.4.2.2 presented the wildlife receptors evaluated in the SLERA using exposure modeling. These receptors are the American dipper (representing insectivorous birds), the mallard (representing omnivorous birds), the belted kingfisher (representing piscivorous birds), and the muskrat (representing herbivorous mammals). Similar to the assumptions used with the aquatic community-level receptors, the exposures to the wildlife receptors were calculated by hydrologic period (i.e., pre-runoff, runoff, and post-runoff).

Wildlife species were assumed to be exposed to COPECs present in the Animas River at and below Silverton by direct ingestion of surface water, incidental ingestion of sediment (except for the belted kingfisher), and by feeding on contaminated food items that accumulated metals from exposure to surface water. The SLERA calculated a total EDD for each wildlife receptor to

estimate their exposure using a standard exposure equation which incorporated species-specific natural history parameters.

Table 4.4 presents the intake equations for each wildlife receptor species. **Table 4.5** provides the species-specific exposure parameters (e.g., body weights, ingestion rates, relative consumption of food items, etc.), as well as the reference sources and assumptions on which these values were based. The SLERA assumed conservatively that the omnivorous mallard fed exclusively on aquatic invertebrates during the "runoff" period to represent females which mainly ingest protein-rich aquatic invertebrates in the spring to prepare for egg laying. The "pre-runoff" and "post-runoff" diets for the mallard were assumed to consist of 50% aquatic invertebrates and 50% aquatic plants.

The exposure calculations assumed that the target wildlife receptors fed on aquatic invertebrates, aquatic plants, or fish. **Table 4.6** provides the literature-derived BCFs for estimating metal concentrations in these food items based on the measured surface water concentrations. Note that no BCFs were found to help estimate metals uptake from surface water into aquatic vascular plants. The exposure calculations used surface water-to-algae BCFs instead.

4.6 Wildlife EDDs

The wildlife EDDs were calculated using the input parameters summarized in **Tables 4.4, 4.5, and 4.6**. The results of these exposure calculations are provided in **Table 4.7** (American dipper), **Table 4.8** (mallard), **Table 4.9** (belted kingfisher), and **Table 4.10** (muskrat).

5.0 RISK CHARACTERIZATION

5.1 Introduction

The SLERA quantified the potential for ecological risk during risk characterization. This phase, which represents the last stage of the SLERA, was built around three sequential steps: 1) risk estimation, 2) uncertainty analysis, and 3) risk description.

The exposure analysis and effects analysis described in previous sections of this SLERA were integrated to determine the likelihood of adverse effects to the assessment endpoints, given the assumptions inherent in the analysis phase. The uncertainty analysis provided a context for the influences of those assumptions on the risk characterization process. Finally, the risk findings were summarized, interpreted, and discussed in the risk description section, using the available lines of evidence to address the risk estimates, as well as the uncertainties associated with them.

Risk was quantified entirely using the HQ method. **Table 5.1** summarizes the risk estimation approach for each measure of effect evaluated in the SLERA. The HQ method compared measured exposures (i.e., surface water and sediment EPCs) or estimated exposures (wildlife EDDs) to corresponding toxicity values (i.e., surface water or sediment screening benchmarks and wildlife no-effect TRVs).

A COPEC-specific HQ was then calculated using the following general equation:

$$HQ = EPC \text{ or } EDD/\text{benchmark or } TRV$$

Where:

HQ	=	Hazard Quotient (unitless)
EPC	=	Exposure Point Concentration (µg/L or mg/Kg)
EDD	=	Estimated Daily Dose (mg/Kg bw.d)
Benchmark	=	surface water or sediment screening benchmark (µg/L or mg/Kg)
TRV	=	wildlife no-effect Toxicity Reference Value (mg/Kg bw.d)

HQs equal to or above 1.0 identified a potential for ecological risk under the conservative exposure and toxicity assumptions used in this evaluation.

Besides assessing the potential impacts associated with worst-case (i.e., maximum) exposures, the risk characterization for benthic invertebrates and fish exposed to surface water also viewed each surface water sample as representing an individual event in which organisms

were exposed to site-derived COPECs. Hence, HQs were calculated for all available surface water samples and were used to form "scatter plots" by sampling station and period. The assessment endpoints for these two aquatic receptor groups were based on the sustainability of the exposed community. Risk to some individuals in a community may be acceptable if the community as a whole remains healthy and stable over time. It was assumed that community-level risks were unlikely to occur if all the HQs measured within a period across years fell below 1.0. On the other hand, community-level risks were more likely to occur if most or all of the HQs within a period across years exceeded 1.0. Finally, some individuals could be impacted, but without resulting in community-level effects, if only a small portion of the HQs within a season across years exceeded 1.0.

The risk characterization did not quantify "incremental risk" by subtracting reference risk from site risk. No reference samples were collected from mainstem Cement Creek and mainstem Mineral Creek. Samples were available from a reference location on the Animas River above Silverton. These data were discussed in the uncertainty analysis to provide better context to the potential risks identified in the Animas River at and below Silverton.

Uncertainty was inherent in this SLERA because many conservative assumptions were made in order to proceed with the investigation. These assumptions affect all aspects of the assessment, including the CSM, the effects analysis, the exposure analysis, and the risk characterization. The uncertainty analysis identified and discussed the major assumptions made in the SLERA. It also provided a short description to determine if each assumption was likely to have overestimated or underestimated the potential for ecological risk. The end result was a balanced overview of uncertainty to help risk managers understand the full extent of potential ecological risk to receptors living or feeding in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton.

5.2 Community-Level Receptors - Benthic Invertebrates

Maintain a stable and healthy benthic invertebrate community: *Are the metal levels in sediment (Animas River at and below Silverton only) or surface water (mainstem Cement Creek and mainstem Mineral Creek only) high enough to impair the benthic invertebrates in these three waterways?*

The potential for ecological risk to the benthic invertebrate community in the three waterways was assessed using one measure of effect, as follows.

1.A Compare the maximum total metal levels measured in sediment samples (Animas River at and below Silverton) or dissolved metals measured in surface water samples (mainstem

Cement Creek and mainstem Mineral Creek) to screening-level sediment and surface water benchmarks, respectively.

5.2.1 Mainstem Cement Creek

Tables 5.2 and 5.3 present the screening-level HQs for the benthic invertebrates exposed to surface water in mainstem Cement Creek. No sediment samples were collected from this EU; therefore, the risk characterization uses surface water data only. The samples were collected at three locations, namely CC21 (across from the historic town of Gladstone), CC41 (midway between Gladstone and Silverton), and CC48 (at the mouth of the creek right before the confluence with the Animas River in Silverton). CC21 and CC41 were only sampled once (May of 2012), whereas CC48 was sampled multiple times.

- **pH**

The minimum pH fell below the benchmark at all three locations during all three hydrologic periods, suggesting the potential for severe risk to the aquatic invertebrate community from exposure to acidity throughout the year.

- **Metals**

The maximum concentrations of all metals exceeded their chronic toxicity screening benchmarks during one or more of the hydrologic periods. By far the largest exceedances were for dissolved Al during the pre-runoff period (HQ = 97.1) and the post-runoff period (HQ = 90.2). The risk associated with several other metals (e.g., Cu, Pb, and Zn) was relatively smaller, but was highest during the runoff period. Note that the risk from Ag is uncertain because it is based on half of the analytical detection limit, as opposed to a detected concentration.

No consistent pattern was observed in terms of the risk from metals from upstream to downstream in mainstem Cement Creek during the runoff period, the only time that surface water samples were collected at all three sampling locations. The risk increased downstream for Al (HQs of 13.7, 27.7, and 33.2 at CC21, CC41, and CC48, respectively) and Pb (HQs of 1.9, 3.1, and 4.8 at CC21, CC41, and CC48, respectively), but went the opposite way for Zn (HQs of 9.9, 6.7, and 6.2 at CC21, CC41, and CC48, respectively). Some metals showed no apparent pattern at all (e.g., Fe and Cu).

5.2.2 Mainstem Mineral Creek

Tables 5.2 and 5.3 present the screening-level HQs for the benthic invertebrates exposed to surface water in mainstem Mineral Creek. No sediment samples were collected from this EU such that the risk characterization relies on surface water data only. All samples were collected at one location (M34) by the mouth of the creek, directly upstream of the confluence with the Animas River in Silverton.

- **pH**

  The minimum pH fell below the benchmark during the pre-runoff (pH = 4.97) and post-runoff (pH = 5.62) periods, with the lowest pH measured in the winter. The lowest pH during the runoff period (pH = 6.49) staid above its benchmark (i.e., low potential for significant risk).

- **Metals**

  The maximum concentrations of all metals, except for Pb and Mn, exceeded their chronic toxicity screening benchmarks during one or more of the hydrologic periods. However, these exceedances were relatively minor, except for dissolved Al during the pre-runoff period (HQ = 54). Note that the risk from Ag is uncertain because it is based on half of the analytical detection limit, as opposed to a detected concentration.

  In general, the highest risk to benthic invertebrates associated with maximum exposures to surface water COPECs in mainstem Mineral Creek occurred during the pre-runoff period, followed by the post-runoff period. The lowest (relative) risk occurred during the runoff period.

5.2.3 Animas River at and below Silverton

Table 5.4 presents the screening-level HQs for benthic invertebrates exposed to sediment in the Animas River at and below Silverton. Three sediment samples were collected from this EU in May 2012; therefore, the risk characterization pertains only to the runoff period.

- **Metals**

  The maximum concentration of all the metals exceeded their no-effect sediment benchmarks, except for Be and Se, which did not have benchmarks. The highest exceedance was for Pb (HQ = 26.5), followed by Zn (HQ = 18.5), and Cu (HQ = 11.7).

5.2.4 Risk conclusions for benthic invertebrates

Mainstem Cement Creek: The chemical conditions in the surface water of mainstem Cement Creek were expected to be highly toxic to benthic invertebrates, particularly due to low pH and high dissolved Al, and to a lesser extent due to the presence of Cd, Cu, Fe, and Zn. The results of the analysis strongly suggested that a functioning benthic invertebrate community would not be able to survive in this creek under current conditions.

Mainstem Mineral Creek: The chemical conditions in the surface water of mainstem Mineral Creek were less severe than in mainstem Cement Creek for benthic invertebrates. However, severe pH drops and high levels of dissolved Al during the pre-runoff period suggested that the benthic invertebrate community may experience high stress in the winter, but could possibly recover during the remainder of the year. The results suggested that the benthic invertebrate community in mainstem Mineral Creek would likely experience high stress under current conditions.

Animas River at and below Silverton: The metal concentrations measured in the substrate of the Animas River at and below Silverton were expected to be highly toxic to benthic invertebrates. Sediment samples were only collected in May 2012. The SLERA assumed that seasonal variations in sediment COPEC levels would be relatively minor, such that the available metals data represented exposure conditions throughout the year. Seasonal variation in sediment contamination can only be addressed by collecting more sediment samples from the Animas River at and below Silverton at other times of the year as part of a future investigation. The results suggested that the benthic invertebrate community in the Animas River at and below Silverton would likely experience high stress under current conditions.

5.3 Community-Level Receptors - Fish

Maintain a stable and healthy fish community: *Are the metal levels in surface water high enough to impair fish in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton?*

The potential for ecological risk to fish in the three waterways was assessed using one measure of effect, as follows.

2.A Compare the maximum dissolved metal levels measured in surface water samples to screening-level surface water benchmarks.

5.3.1 Mainstem Cement Creek

The risk characterization for fish in Mainstem Cement Creek is identical to the benthic invertebrate analysis summarized in Section 5.2.1. The reason is that both receptor groups were evaluated for exposure to surface water using the same maximum COPEC concentrations and chronic surface water toxicity benchmarks.

5.3.2 Mainstem Mineral Creek

The risk characterization for fish in Mainstem Mineral Creek is identical to the benthic invertebrate analysis summarized in Section 5.2.1. The reason is that both receptor groups were evaluated for exposure to surface water using the same maximum COPEC concentrations and chronic surface water toxicity benchmarks.

5.3.3 Animas River at and below Silverton

Tables 5.2 and 5.3 present the screening-level HQs for fish exposed to surface water in the Animas River at and below Silverton (note: this surface water evaluation can also be used directly on the benthic invertebrate community if one desires to assess the impact of surface water on this receptor group. The reason is that the chronic surface water screening benchmarks used in this evaluation are protective of both fish and benthic invertebrates).

- **pH**

  The minimum pH fell below the benchmark during the pre-runoff and post runoff periods, with the lowest pH measured in the winter. The lowest pH remained above its minimum benchmark during the runoff period (i.e., no potential for significant risk).

- **Metals**

  The maximum concentrations of all metals, except for Pb, exceeded their chronic toxicity screening benchmarks during one or more of the runoff periods. However, these exceedances were relatively minor, except for dissolved Al during the pre-runoff period (HQ = 37.8). The risk from Ag is uncertain because it is based on half of the analytical detection limit, as opposed to a detected concentration.

  In general, the highest relative risk to fish associated with maximum exposures to surface water COPECs occurred during the pre-runoff period, followed by the post-runoff period. The lowest relative risk occurred during the runoff period.

5.3.4 Risk from all surface water HQs combined

A SLERA is, by definition, a conservative evaluation which assesses the potential for ecological risk based on maximum exposures. However, an additional assessment was performed for this project by calculating, plotting, and comparing all of the surface water HQs (instead of only the maximum values) measured across the three EUs and the Animas River above Silverton (reference). The approach consisted of the following steps:

- Organize the analytical data by EU and sampling date (i.e., pre-runoff period, runoff period, and post-runoff period).
- Calculate the HQs for the dissolved metal COPECs, including hardness-adjusted HQs for the hardness-sensitive metal COPECs, for each surface water sample collected between May 2009 and May 2012 from the three EUs and the Animas River above Silverton (reference).
- Plot the HQs by hydrologic period, i.e., pre-runoff, runoff, and post-runoff, and by EU to allow for direct visual comparison.

Appendix 3 summarizes the HQ calculations by dissolved metal COPEC, whereas **Figures 5.1 to 5.8** show the results of these calculations plotted by hydrologic period and EU. Note that pH was also included, but not as HQs. Instead, each pH value was plotted for comparison against the pH screening benchmark of 6.0.

The outcome of this expanded graphical analysis is summarized below:

- The HQs for dissolved Cd and Zn were substantially lower in mainstem Mineral Creek compared to the Animas River above Silverton (reference). This pattern suggested that the watershed of the Animas River above Silverton serves as a source for these two metals to the Animas River at and below Silverton. This relatively high risk also masked the signal for the dissolved Cd and Zn HQs from mainstem Cement Creek entering the Animas River in Silverton (see **Figures 5.1 and 5.5**).
- Mainstem Cement Creek carried a substantial "risk load" of dissolved Cu (all three periods), dissolved Pb (runoff period only), and dissolved Fe (all three periods). However, the potential impact of those "risk loads" on the Animas River at and below Silverton were negligible for Cu (see **Figure 5.2**), non-existent for Pb (see **Figure 5.3**), and small for Fe (see **Figure 5.7**). This pattern appears to reflect substantial differences in surface water flow volumes between the two waterways, resulting in high dilution ratios in the Animas River at and below Silverton.

- Mainstem Cement Creek also carried a substantial "risk load" of dissolved Al (all three periods; note the logarithmic scale in **Figure 5.6**) and acidity (all three periods; see **Figure 5.8**). The potential impacts of those COPECs on the Animas River at and below Silverton were substantial for Al during the pre-runoff and post-runoff periods, and for acidity during the pre-runoff period. This pattern suggested that the high dilution ratios between mainstem Cement Creek and the Animas River at and below Silverton were overwhelmed by the extreme amounts of dissolved Al and acidity present in mainstem Cement Creek. It would appear that any site-specific community-level impacts that may be present in the Animas River at and below Silverton could be explained largely by the high levels of dissolved Al in the pre- and post-runoff periods, and the low pH levels during the runoff period.

5.3.5 Risk Conclusions for fish

Mainstem Cement Creek: The chemical conditions in mainstem Cement Creek were highly toxic to fish, particularly due to low pH and high dissolved Al, and to a lesser extent by the presence of Cd, Cu, Fe, and Zn. The results of the analysis strongly suggested that a functioning fish community would not be able to survive in this creek under current conditions.

Mainstem Mineral Creek: The chemical conditions in mainstem Mineral Creek were less severe than in mainstem Cement Creek for the local fish community. However, severe pH drops and high levels of dissolved Al during the pre-runoff period suggested that fish may experience high stress in the winter, but could possibly recover during the remainder of the year. The results suggested that the fish community in mainstem Mineral Creek would likely experience high stress under current conditions.

Animas River at and below Silverton: The chemical conditions in the Animas River at and below Silverton reflected input from both the Animas River above Silverton (Cd and Zn) and from mainstem Cement Creek and mainstem Mineral Creek (Al and pH, with lesser inputs of Fe and Cu). The results strongly suggested that the fish community in the Animas River at and below Silverton would experience high stress under current conditions.

5.4 Aquatic insectivorous birds

Risk to aquatic insectivorous birds represented by the American dipper feeding on aquatic insects in the Animas River at and below Silverton was assessed based on one measure of effect, i.e., use generic BCFs to estimate COPEC levels in aquatic invertebrates and apply a conservative food chain model to calculate daily doses for comparison to no-effect bird TRVs.

This measure of effect identified Al, Cu, Pb, and Zn as the major risk drivers to insectivorous birds ingesting surface water, sediment, and aquatic invertebrates from the Animas River at and below Silverton. Cd, Cr and Se also had HQs exceeding 1.0, but are excluded from this discussion because they were only minor risk drivers. The potential risks associated with the four major COPECs are discussed below. The reliability of the findings was low because it was based on a single, semi-qualitative Line of Evidence (LOE).

Table 5.5 presents the no-effect HQs for the American dipper feeding during the pre-runoff, runoff, and post-runoff period in the Animas River at and below Silverton. **Figure 5.9** shows the same data in a graph.

The risks to aquatic insectivorous birds can be summarized as follows:

Aluminum
The no-effect HQs for Al based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 81.1 to 131. The highest HQ was observed during the pre-runoff period.

Copper
The no-effect HQs for Cu based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 27.8 to 34.1. The highest HQ was observed during the post-runoff period.

Lead
The no-effect HQs for Pb based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 17.3 to 256. The highest HQ was observed during the runoff period.

Zinc
The no-effect HQs for Zn based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 17.4 to 72.8. The highest HQ was observed during the pre-runoff period.

5.5 Aquatic omnivorous birds

Risk to omnivorous birds represented by the mallard feeding in the Animas River at and below Silverton was assessed based on one measure of effect, i.e., use generic BCFs to estimate COPEC levels in benthic invertebrates and aquatic plants and apply a conservative food chain model to calculate daily doses for comparison to no-effect bird TRVs.

This measure of effect identified Al, Cu, Pb, and Zn as the major risk drivers to omnivorous birds ingesting surface water, sediment, benthic invertebrates, and aquatic plants from the Animas River at and below Silverton. Cd, Cr and Se also had HQs exceeding 1.0, but are excluded from this discussion because they were only minor risk drivers. The potential risks associated with the four major COPECs are discussed below. The reliability of the findings was low because it was based on a single, semi-qualitative LOE.

Table 5.6 presents the no-effect HQs for the mallard feeding during the pre-runoff, runoff, and post-runoff period in the Animas River at and below Silverton. **Figure 5.10** shows the same data in a graph.

The risks to aquatic omnivorous birds can be summarized as follows:

Aluminum
The no-effect HQs for Al based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 19.0 to 35.4. The highest HQ was observed during the runoff period.

Copper
The no-effect HQs for Cu based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 6.8 to 10.4. The highest HQ was observed during the runoff period.

Lead
The no-effect HQs for Pb based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 4.5 to 96.7. The highest HQ was observed during the runoff period.

Zinc
The no-effect HQs for Zn based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 6.6 to 20.9. The highest HQ was observed during the pre-runoff period.

5.6 Piscivorous birds

Risk to piscivorous birds represented by the belted kingfisher feeding in the Animas River at and below Silverton was assessed based on one measure of effect, i.e., use generic BCFs to estimate COPEC levels in fish and apply a conservative food chain model to calculate daily doses for comparison to no-effect bird TRVs.

This measure of effect identified Cu and Zn as the major risk drivers to piscivorous birds ingesting surface water and fish from the Animas River at and below Silverton. The potential risks associated with these major COPECs are discussed below. The reliability of the findings was low because it was based on a single, semi-qualitative LOE.

Table 5.7 presents the no-effect HQs for the belted kingfisher feeding during the pre-runoff, runoff, and post-runoff period in the Animas River at and below Silverton. **Figure 5.11** shows the same data in a graph.

The risks to piscivorous birds can be summarized as follows:

Copper

The no-effect HQs for Cu based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 3.2 to 4.1. The highest HQ was observed during the post-runoff period.

Zinc

The no-effect HQs for Zn based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 4.8 to 20.6. The highest HQ was observed during the pre-runoff period.

5.7 Aquatic herbivorous mammals

Risk to aquatic herbivorous mammals represented by the muskrat feeding in the Animas River at and below Silverton was assessed based on one measure of effect, i.e., use generic BCFs to estimate COPEC levels in aquatic plants and apply a conservative food chain model to calculate daily doses for comparison to no-effect mammal TRVs.

This measurement endpoint identified Al, Pb, and Zn as the major risk drivers to herbivorous mammals ingesting surface water, sediment, and aquatic plants from the Animas River at and below Silverton. As, Cd, Cr, Cu and Se also had one or more HQs above 1.0, but are excluded from this discussion because they were only minor risk drivers. The potential risks associated with the three major COPECs are discussed below. The reliability of the findings was low because it was based on a single, semi-qualitative LOE.

Table 5.8 presents the no-effect HQs for the muskrat feeding during the pre-runoff, runoff, and post-runoff period in the Animas River at and below Silverton. **Figure 5.12** shows the same data in a graph.

The risks to aquatic herbivorous mammals can be summarized as follows:

Aluminum

The no-effect HQs for Al based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 405 to 654. The highest HQ was observed during the pre-runoff period.

Lead

The no-effect HQs for Pb based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from < 1.0 to 13.7. The highest HQ was observed during the runoff period.

Zinc

The no-effect HQs for Zn based on maximum exposure in the Animas River at and below Silverton during the three hydrologic periods ranged from 3.2 to 13.0. The highest HQ was observed during the pre-runoff period.

5.8 General Risk Conclusions

The conclusions from the risk analysis are as follows:

- The surface water conditions were uniformly worse in mainstem Cement Creek, as compared to mainstem Mineral Creek and the Animas River at and below Silverton. However, the total risk to community-level aquatic receptors from COPECs in surface water flowing in the Animas River at and below Silverton was due to a combination of (a) unknown sources of dissolved cadmium and zinc in the Animas River above Silverton, (b) high levels of dissolved aluminum and acidity in the Animas River at and below Silverton which originate in the Cement Creek and Mineral Creek watershed, and (c) lower, but still substantial levels of several other metals.

- The metal concentrations in the substrate of the Animas River at and below Silverton were expected to be highly toxic to benthic invertebrates, such that this community was expected to experience high stress from exposure to site-related contamination.

- The modeled estimated daily exposures to metals in surface water, sediment, and food items ingested by the four species of wildlife receptors feeding at the Animas River at and below Silverton exceeded no effect wildlife TRVs. These exceedances suggested the potential for significant population-level risks, based on the prevailing (but conservative) assumptions used in the SLERA.

5.9 Uncertainty Analysis

Uncertainty is inherent in any ecological risk assessment due to incomplete or inadequate knowledge about a number of key input parameters. This lack of knowledge is usually addressed by making exposure and toxicity estimates using the limited available data, or by making conservative assumptions based on guidance and best professional judgment when no reliable data are available. Overall, the results of this SLERA are expected to be biased on the conservative side because "worst-case" exposures (e.g., maximum COPEC concentrations) and no-effect screening benchmarks and TRVs were used to calculate risk.

The major uncertainties are discussed below.

5.9.1 Community-level receptors

General observations

- It is unclear if mainstem Cement Creek or Mineral Creek upstream of the confluence with South Fork Mineral Creek supported aquatic life before mining activities started in their watersheds in the 19th century (Church *et al.*, 2007). If this observation is correct, then any impairment may not reflect negatively on current conditions. This situation represents a serious uncertainty which would have to be considered as part of any future risk management decision-making process.

- The surface water exposures evaluated in the SLERA were based on dissolved metal concentrations, which represent the toxicologically "active" fraction of the total metals. Basing the surface water exposures on this fraction was not overly conservative and did not generate much uncertainty.

- The surface water exposures, however, represented "worst-case" conditions, i.e., the maximum concentration of each COPEC measured over a three-year period during the pre-runoff, runoff, and post-runoff periods at the various EUs. These maximum concentrations, while potentially highly toxic at the time they occurred, do not represent the range of conditions experienced over time by the local fish and invertebrate communities. The SLERA approach overestimated these risks.

- Some of the community-level risk identified with surface water COPECs in the Animas River at and below Silverton was associated with unknown contaminant sources in the Animas River above Silverton. This observation pertains particularly to Cd (see **Figure 5.1**) and Zn (see **Figure 5.5**). The presence of this "reference" risk, at least for some of

the surface water COPECs, indicated that the site-related risks for those COPECs were overly conservative.

- The SLERA assumed that fish were exposed to site-related contamination exclusively via surface water. While it is likely that surface water serves as the primary exposure route to fish, secondary exposure could also occur from ingesting contaminated prey or from direct contact with contaminated sediment. These two secondary exposure routes could not be quantified and were therefore ignored, which may have underestimated actual risk to fish. Note that the available sediment screening benchmarks were developed based on effects to benthic invertebrates only. No sediment benchmarks exist to assess effects of sediment contamination to fish.

- Risk to community-level receptors was assessed entirely using the HQ method. The HQs were not summed to calculate a Hazard Index (HI), because a HI assumes that HQs are additive. It is not anticipated that all of the inorganic COPECs evaluated in this SLERA would exert their toxic effects on one and the same organ, which is a basic requirement for calculating HIs. On the other hand, it is possible that some of the COPECs may exert additive toxicity, in which case the HQ approach may have underestimated certain risks. Note that this observation applied equally to the wildlife evaluation.

Benthic invertebrate community

- No recent sediment samples were available from mainstem Cement Creek and mainstem Mineral Creek for use in the SLERA. Instead, surface water was retained as the only exposure medium for the benthic invertebrate community in these two EUs. It appears reasonable to assume that invertebrates associated with the coarse substrate in high-energy streams will experience some of their total exposure from the overlying surface water. However, the degree to which the actual exposure by benthic invertebrates in these two EUs is associated with COPECs in (unmeasured) bulk sediment and/or pore water is unknown, and hence represents an uncertainty.

- Using this same line of reasoning, it is not known how much of the exposure by the benthic community in the Animas River at and below Silverton was strictly based on sediment (as was assumed in the measurement endpoint for this receptor group) versus the overlying surface water. It seems appropriate to assume that an unknown fraction of the total exposure would be associated with surface water COPECs. That uncertainty can be mitigated by examining the fish HQs, since those values were calculated using chronic toxicity screening benchmarks which are equally protective of fish and invertebrates, and the same maximum exposure concentrations.

- The SLERA assumed that benthic invertebrates were exposed to site-related contamination exclusively via surface water (Cement and Mineral Creeks) or sediment (Animas River at and below Silverton). While it is likely that these two matrices serve as the primary exposure route to benthic invertebrates, secondary exposure could also occur from ingesting contaminated prey. This secondary exposure route could not be quantified and was therefore ignored, which may have underestimated actual risk to the benthic invertebrate community.

- Bulk sediment data can be poor predictors of toxicity due to unaccounted differences in metal bioavailability between samples. Pore water data can provide a stronger measure of the chemical conditions experienced by benthic invertebrates living in the substrate (EPA, 2005). Pore water data were not collected at any of the sediment sampling locations in the Animas River at and below Silverton for comparison to chronic surface water benchmarks. The lack of such data increased the uncertainty of the risk conclusions which were derived from the bulk sediment data evaluated in the SLERA.

- Similarly, no data on Acid Volatile Sulfide (AVS) or Simultaneously Extracted Metals (SEM) were available for the divalent metals Cd, Cu, Pb, Ni, Ag, and Zn in the three sediment samples collected from the Animas River at and below Silverton in May 2012. AVS-SEM measures the bioavailability, and hence the toxicity, of divalent metals in sediment based on the equilibrium partitioning approach as outlined in EPA (2005). Such information would have provided an additional LOE for use in the risk characterization. This line of reasoning assumes that the substrate in the Animas River at and below Silverton is fine enough (i.e., not too coarse) to be able to create the chemical conditions needed to generate AVS in the first place. It is not known if those conditions exist in that section of the Animas River.

5.9.2 Wildlife receptors

- The exposure modeling used conservative/generic surface water-to-biota partition coefficients (i.e., BCFs), instead of field-collected tissue samples, to estimate COPEC levels in aquatic invertebrates, fish, and plants. It was not known how well the literature-derived BCFs reflected site-specific contaminant uptake and tissue levels that may exist in the Animas River at and below Silverton, resulting in uncertainty. In addition, the plant BCF for the herbivores was based on algae because no vascular aquatic plant BCFs were available. It is not known if or how metal uptake differs between algae and vascular aquatic plants, resulting in uncertainty about actual risk to the omnivorous birds and the herbivorous mammals feeding on aquatic plants.

- The exposure modeling estimated the tissue residue levels in aquatic food items from the Animas River at and below Silverton by multiplying a COPEC-specific BCF by the maximum *total* metal concentration, instead of the *dissolved* metal concentration. This conservative approach overestimated some of the wildlife risks, particularly for Al and Pb. The attachment below shows the difference between the total and dissolved concentrations. Using the latter in the exposure modeling would have resulted in substantially lower HQs for these two metals.

Max EPC (ug/L)	pre-runoff period	runoff period	post-runoff period
ALUMINUM			
total	4,440	3,060	2,750
dissolved	3,290	50	193
RATIO	*1.3*	*61*	*14.3*
LEAD			
total	14.7	99.8	7.0
dissolved	2.7	0.5	0.5
RATIO	*5.4*	*200*	*14*

note: the maximum EPCs are from Appendix 1.c (aluminum) and Appendix 1.j (lead)

- The exposure modeling used literature-derived life history parameters for the target receptors. Conservative assumptions were used when species-specific information was not available in order to derive a missing life history variable (i.e., ingestion rates). The impact of these assumptions on the risk estimates are presumed to be small.

- The exposure modeling used "worst-case" surface water and sediment COPEC levels to estimate the wildlife doses. The resulting risk estimates are unrealistically high and unlikely to be experienced by wildlife receptors feeding in the Animas River at and below Silverton over a season. This conservative SLERA approach resulted in the risk conclusions with high levels of uncertainty.

- The exposure modeling assumed that the Animas River at and below Silverton equaled a wildlife receptor's entire home range/forage range (i.e., area use factor = 1.0). This assumption was not unrealistic, given that the surface water and sediment samples represented a substantial stretch of the river.

- The exposure modeling included sediment ingestion. The substrate composition of the Animas River at and below Silverton is unknown but it appears reasonable to assume that

those substrates may include large fractions of coarser sands, gravels, pebbles, and cobbles, instead of the fine sands/silts expected to be ingested by wildlife receptors during feeding. The actual incidental sediment ingestion may be lower than assumed in the food chain models, which increases the uncertainty of the calculated risks.

- The characterization of exposure assumed that enough aquatic invertebrates, fish, and aquatic plants were present in the Animas River at and below Silverton to feed the four wildlife receptor populations evaluated in the SLERA. This assumption was speculative in light of the presence of aquatic toxicity identified in the surface water and sediment collected from the Animas River at and below Silverton. Instead, it seems more reasonable to assume that the invertebrates, fish, and plants in this stretch of the river are impacted and therefore may not be available in the quantities required to support the wildlife receptors as assumed in the food chain models. If so, then the estimated exposures, and the resulting risks, may be more hypothetical than real.

- The effects assessment for the wildlife receptors used published no-effect TRVs to estimate COPEC toxicity. The assessment endpoints focused on preserving populations, whereas TRVs are derived from data on individuals of a test species. Extrapolating individual effects to higher levels of ecological organization is inherently uncertain, particularly because these extrapolations are applied across non-related species (e.g., chicken to belted king fisher, or mouse to muskrat). Also, the risks were calculated in terms of no-effect HQs. Using effect TRVs for birds and mammals, which are typically two to ten times higher than no-effect TRVs, would reduce the current HQs by a factor of two to ten.

- The wildlife TRVs apply to all birds or mammals. Hence, the same COPEC-specific TRVs were used for the American dipper, mallard, and belted kingfisher. It is unknown how much more, or less, sensitive these three receptors species might be compared to the test species employed to generate the TRVs used in this SLERA. Using "one-size-fits-all" TRVs creates much uncertainty about the actual toxicity of a COPEC to the target wildlife receptor. However, the TRV-derivation process is conservative by design, such that it appears more likely that the wildlife risks were overestimated rather than underestimated.

- The consistent use of conservative assumptions (such as assuming 100% of contaminant bioavailability in food items, assuming feeding in a habitat which may lack food items, relying on TRVs derived from wildlife toxicity tests using soluble or other highly bioavailable fractions of the test chemical, and using conservative TRVs, when possible) most likely greatly overestimated risk to the wildlife receptors feeding in the Animas

River at and below Silverton. As a result, the actual risk to wildlife receptors may be substantially lower than reported in this SLERA.

- The belted kingfisher was selected as the avian piscivore for use in food chain modeling in the SLERA. This species was assumed not to ingest sediment based on its feeding habit of catching fish from within the water column and ingesting them on perches along the shoreline. Using the belted kingfisher may have underestimated the potential for risk to this feeding guild because the levels of some metals in sediment collected from the Animas River at and below Silverton were high enough to add substantially to the daily dose. The potential underestimation of risk to avian piscivores can be minimized in future food chain modeling efforts by selecting a bird species, such as the great blue heron, which is known to ingest sediment while feeding.

- The American dipper dives to the bottom of waterways to feed on benthic invertebrates, whereas the southwestern willow flycatcher eats insects "on the wing" or by gleaning them from riparian vegetation. As a result, the diet of the American dipper is essentially aquatic (+ includes sediment ingestion), whereas the diet of the willow flycatcher includes a substantial portion of terrestrial insects (Drost et al., 2001) and no sediment ingestion. It seems probable that the screening-level risk to the American dipper described in this SLERA may overestimate the risk to willow flycatchers that may feed and breed in the riparian habitat of the Animas River at and below Silverton.

5.10 Recommended scientific management decision point

According to the eight-step ecological risk assessment process, completing Step 2 of the SLERA represents a stage in the process where a scientific management decision point is reached. Either the available evidence shows that ecological risk is absent or unlikely and the process stops, or the evidence shows that ecological risk is uncertain or present and the investigation continues.

The analysis summarized in this SLERA report showed that the current conditions in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton could generate high levels of ecological risk to community-level and wildlife receptors that live in these three water ways or that feed on the Animas River at and below Silverton.

The evidence is strong enough to show the need for more investigations to better quantify the exposures, the effects, and the risks using more lines of evidence (e.g., surface water and sediment toxicity testing, tissue residue analyses, community surveys), more realistic exposure assumptions (e.g., 95% upper confidence limits and averages), and more realistic effects

assumptions (e.g., effect sediment benchmarks and effect TRVs). Hence, it is recommended to collect more data from this site in support of a future BERA.

6.0 SUMMARY AND CONCLUSIONS

6.1 Introduction

The Animas River flows through the town of Silverton in San Juan County, CO. This waterway is affected by flow which has come in contact with mineralized material, either naturally or as a result of mining activities, such as through the creation of mine adits. The affected water originates in the upper reaches of the two major tributaries of the Animas River in this area, namely Cement Creek and Mineral Creek, and from other tributaries of the Animas River above Silverton. The site-related contamination in the tributaries contains high levels of metals and low pH which are carried downstream to the Animas River at and below Silverton.

The goal of the SLERA was to assess the potential for ecological risk to different types of organisms exposed to site-contaminated surface water, sediment, and food, as follows:

- Benthic invertebrates exposed to (a) surface water in mainstem Cement Creek and mainstem Mineral Creek (Note: No recent sediment samples were available from these two waterways), and (b) sediment in the Animas River at and below Silverton,

- Fish exposed to surface water in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton, and

- Three avian and one mammalian wildlife species exposed via ingestion of surface water, sediment, and food items from the Animas River at and below Silverton.

The surface water data represented dozens of samples collected from the three waterways between May 2009 and May 2012. The sediment data consisted of three samples collected from the Animas River at and below Silverton in May 2012. The available information was reviewed to identify assessment endpoints and measures of effect, and to develop a CSM which showed the movement of site-related contaminants from the sources to the receptors.

The effects evaluation used conservative screening benchmarks obtained from the literature to identify the COPECs in surface water and sediment. These benchmarks, together with no-effect TRVs for birds and mammals, were used to assess the toxicity of these COPECs to benthic invertebrates, fish, and wildlife receptors.

The surface water and sediment COPECs for benthic invertebrates and fish were selected by identifying the metal levels with the highest HQs using the analytical data from May 2009 to May 2012 across the three waterways combined. Those same compounds were also retained as COPECs for the wildlife receptors feeding in the Animas River at and below Silverton.

However, the waterways were subsequently treated as separate EUs to derive the EPCs in the exposure assessment. The exposures associated with surface water were further split into three hydrologic periods, namely the pre-runoff period (February to April), runoff period (May and June), and the post-runoff period (July to November) (Note: No surface water data were available for December or January).

The exposures to the four wildlife receptors feeding in the Animas River at and below Silverton were quantified using a simplified food chain model which calculated an EDD based on ingesting surface water, sediment, and food items. No measured tissue residue data were available for those food items, which consisted of aquatic invertebrates, fish, and aquatic vegetation. Instead, the COPECs in the food items were estimated by multiplying the COPEC levels measured in surface water by published COPEC-specific BCFs.

Risk was quantified entirely using the HQ method, which compares measured exposures (i.e., surface water and sediment EPCs) or estimated exposures (wildlife EDDs) to corresponding toxicity values consisting of surface water or sediment screening benchmarks and wildlife no-effect TRVs.

A COPEC-specific HQ was then calculated using the following general equation:

$$HQ = EPC \text{ or } EDD/\text{benchmark or } TRV$$

Where:

HQ	=	Hazard Quotient (unitless)
EPC	=	Exposure Point Concentration (µg/L or mg/Kg)
EDD	=	Estimated Daily Dose (mg/Kg bw.d)
Benchmark	=	surface water or sediment screening benchmark (µg/L or mg/Kg)
TRV	=	wildlife no-effect Toxicity Reference Value (mg/Kg bw.d)

HQs equal to or above 1.0 identified a potential for ecological risk under the conservative exposure and toxicity assumptions used in this evaluation.

Besides assessing the potential impacts associated with worst-case (i.e., maximum) exposures, the risk characterization for benthic invertebrates and fish also viewed each surface water sample as an individual exposure event in time. Hence, HQs were calculated for all available surface water samples and were used to form "scatter plots" by sampling station and period. Those plots were then used to identify patterns of risk across the waterways and the three exposure periods.

Uncertainty was inherent in the SLERA because many conservative assumptions were made in order to proceed with the investigation. These assumptions affected all aspects of the assessment including the CSM, the effects analysis, the exposure analysis, and the risk characterization. The uncertainty analysis identified and discussed the major assumptions made in the SLERA. It also provided a short description to determine if each assumption was likely to have overestimated or underestimated the potential for ecological risk. The end result was a balanced overview of uncertainty to help risk managers understand the full extent of potential ecological risk to receptors living or feeding in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River at and below Silverton.

6.2 Risk conclusions for benthic invertebrates

Mainstem Cement Creek: The chemical conditions in the surface water of mainstem Cement Creek were expected to be highly toxic to benthic invertebrates, particularly due to high levels of acidity and dissolved Al, and to a lesser extent by the presence of Cd, Cu, Fe, and Zn. The results of the analysis strongly suggested that a functioning benthic invertebrate community would not be able to survive in this creek under current conditions.

Mainstem Mineral Creek: The chemical conditions in the surface water of mainstem Mineral Creek were less severe than in mainstem Cement Creek for the benthic invertebrates. However, severe pH drops and high levels of dissolved Al during the pre-runoff period suggest that the benthic invertebrate community may experience high stress in the winter, but could possibly recover during the remainder of the year. The results suggested that the benthic invertebrate community in mainstem Mineral Creek would likely experience high stress under current conditions.

Animas River at and below Silverton: The metal concentrations measured in the substrate of the Animas River at and below Silverton were expected to be highly toxic to benthic invertebrates. Sediment samples were only collected in May 2012. The SLERA assumed that seasonal variations in sediment COPEC levels would be relatively minor, such that the available metals data represented exposure conditions throughout the year. Only more sediment samples collected from the Animas River at and below Silverton at other times of the year as part of a future BERA sampling effort can address seasonal variation in sediment contamination. The results suggested that the benthic invertebrate community in the Animas River at and below Silverton would likely experience high stress under current conditions.

It is recommended to perform more evaluations within the framework of a BERA in order to better define and quantify the potential for ecological risk to benthic invertebrates.

6.3 Risk conclusions for fish:

Mainstem Cement Creek: The chemical conditions in mainstem Cement Creek were highly toxic to fish, particularly due to high levels of acidity and dissolved Al, and to a lesser extent by the presence of Cd, Cu, Fe, and Zn. The results of the analysis strongly suggested that a functioning fish community would not be able to survive in this creek under current conditions.

Mainstem Mineral Creek: The chemical conditions in mainstem Mineral Creek were less severe than in mainstem Cement Creek for the fish. However, severe pH drops and high levels of dissolved Al during the pre-runoff period suggested that fish may experience high stress in the winter, but could possibly recover during the remainder of the year. The results suggested that the fish community in mainstem Mineral Creek would likely experience high stress under current conditions.

Animas River at and below Silverton: The chemical conditions in the Animas River at and below Silverton reflected input from the Animas River above Silverton (Cd and Zn) and more local input from mainstem Cement Creek and mainstem Mineral Creek (Al and pH, with lesser inputs of Fe and Cu). The results strongly suggested that the fish community in the Animas River at and below Silverton would experience high stress under current conditions.

It is recommended to perform more evaluations within the framework of a BERA in order to better define and quantify the potential for ecological risk to fish.

6.4 Risk conclusions for wildlife receptors:

The modeled estimated daily exposures to metals in surface water, sediment, and food items ingested by the four species of wildlife receptors feeding at the Animas River at and below Silverton exceeded no effect wildlife TRVs. These exceedances suggested the potential for significant population-level risks, based on the prevailing (but conservative) assumptions used in the SLERA. The major risk-driving COPECs consisted of Al, Cu, Pb, and Zn. The highest relative risk was found in the American dipper feeding on aquatic insects (plus ingesting surface water and sediment), whereas the lowest relative risk was found in the belted kingfisher feeding on fish (plus ingesting surface water but not sediment).

It is recommended to perform more evaluations within the framework of a BERA in order to better define and quantify the potential for ecological risk to wildlife receptors feeding in the Animas River at and below Silverton.

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FIGURES

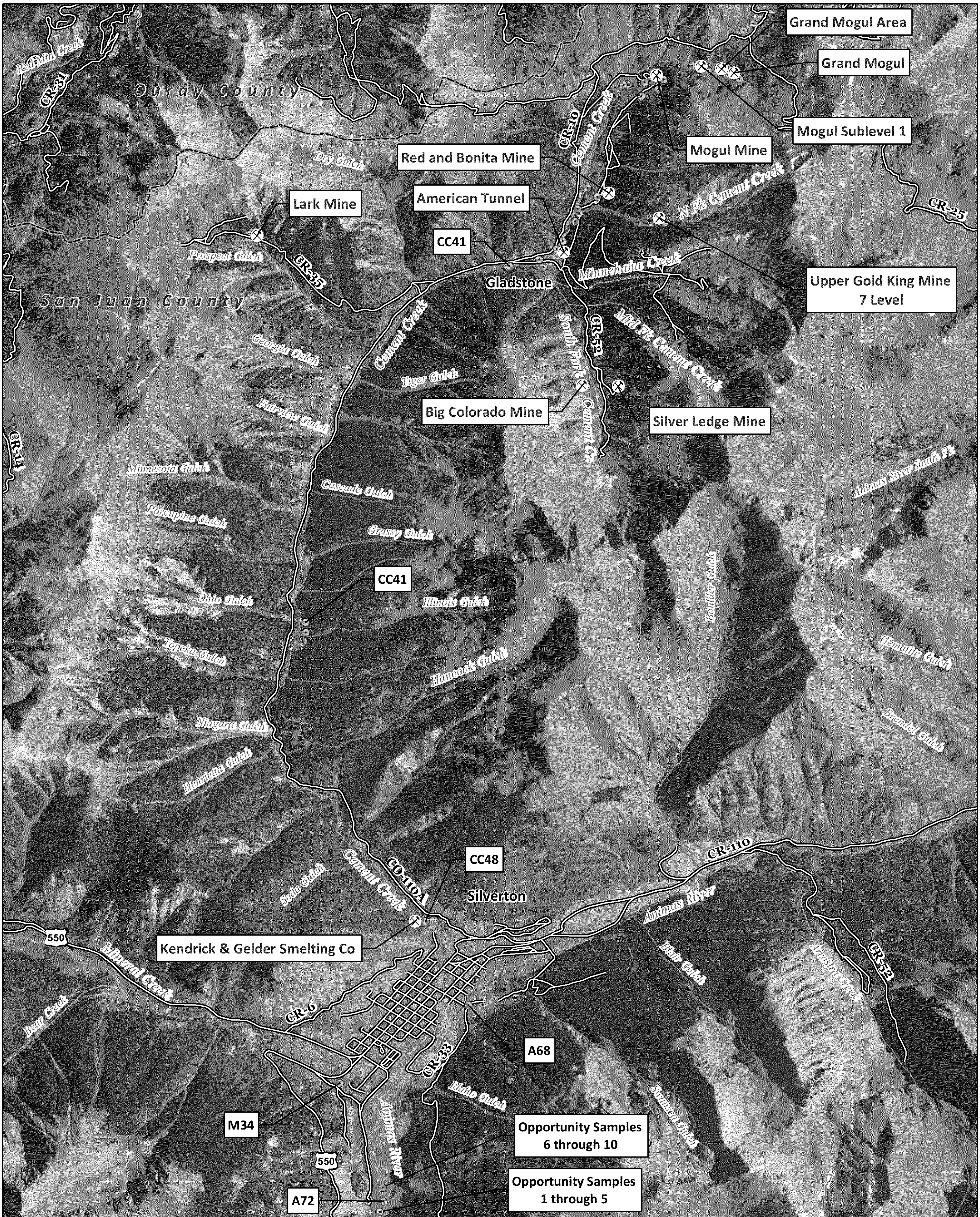


Figure 2.1
Upper Animas Mining District Area Overview
Upper Animas River and Cement Creek, Silverton, CO

TechLaw

- Sample Locations
- Mine Locations
- Rivers and Streams
- Roads
- County Boundaries

Date: August 16, 2012

Data Sources:
Sample Locations: U.S. EPA Region 8 and UOS (2011)
Mine Locations: U.S. EPA and ESAT (2012)
Roads: Navteq (2009)
Rivers and Streams: CDOW 1:24k (2004)
County Boundaries: U.S. Census Bureau (2009)
Image: USDA NAIP (2009)

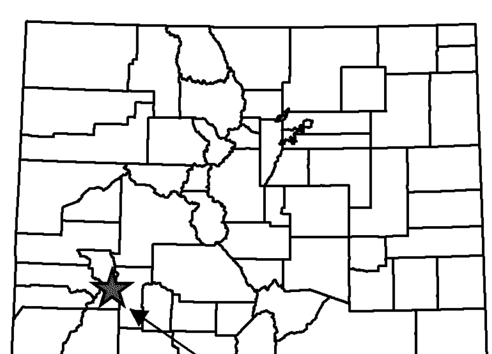
Coordinate System/Projection:
UTM Zone 13 North, NAD 83, Meters

N W E S

0 0.5 1 Miles

0 0.5 1 Kilometers

Colorado



Area of Interest

FIGURE 2.2
Ecological Site Conceptual Model - Aquatic Pathways
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

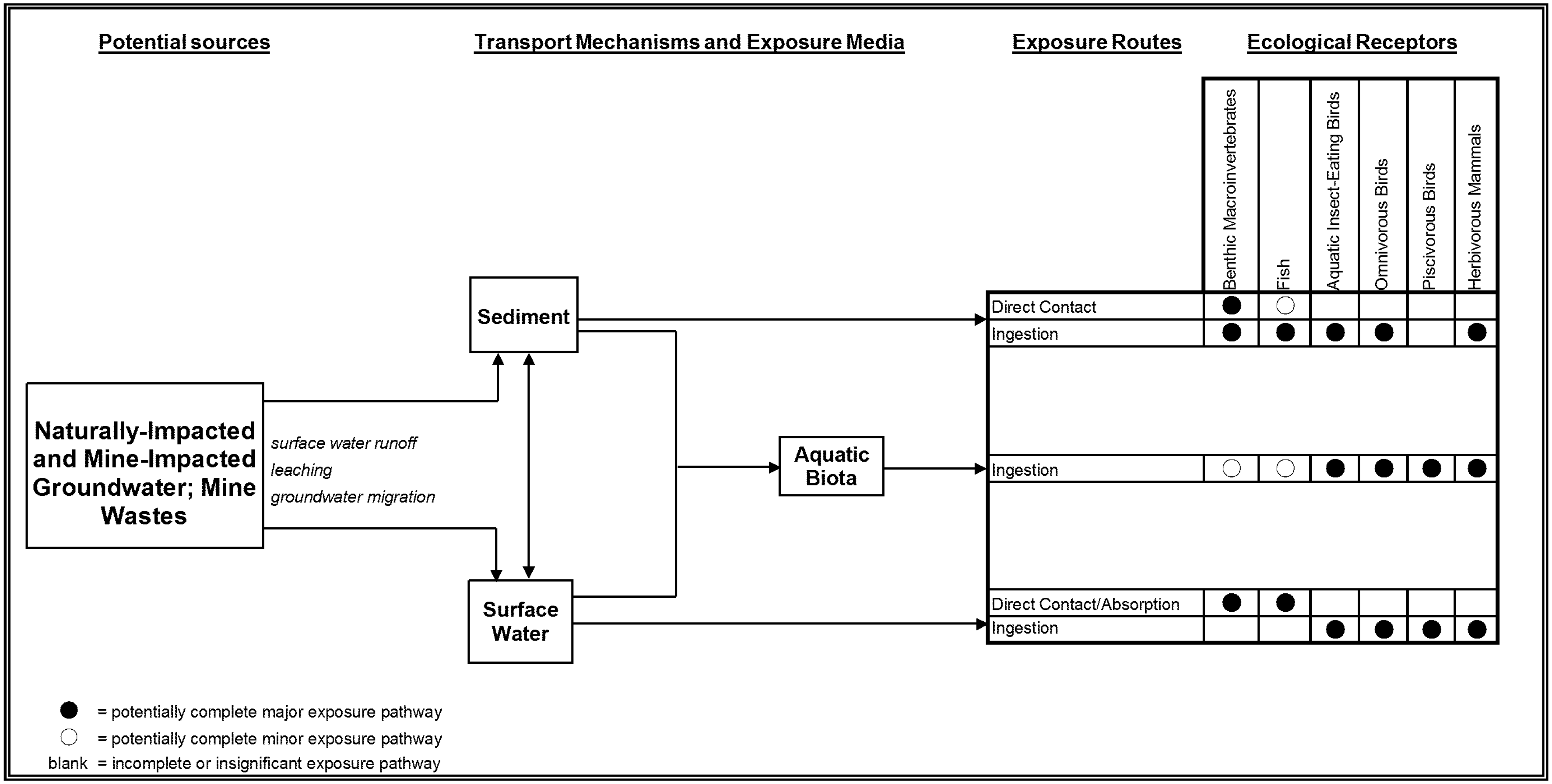


Figure 5.1: Hardness-adjusted dissolved cadmium HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining district in 2009-2012

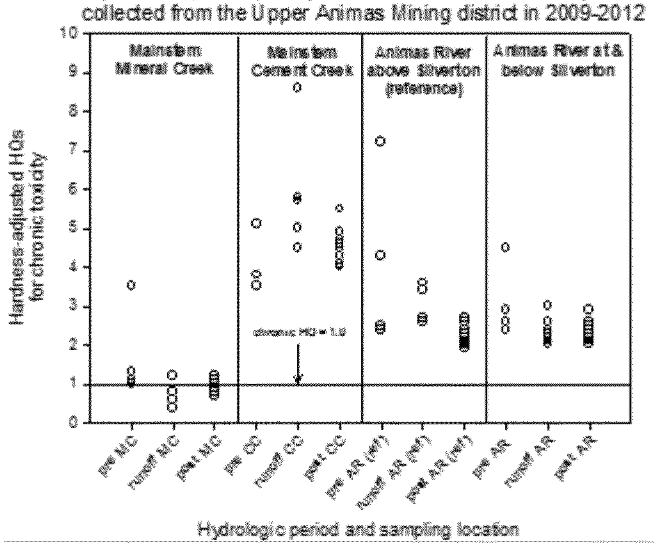


Figure 5.2: Hardness-adjusted dissolved copper HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining District in 2009-2012

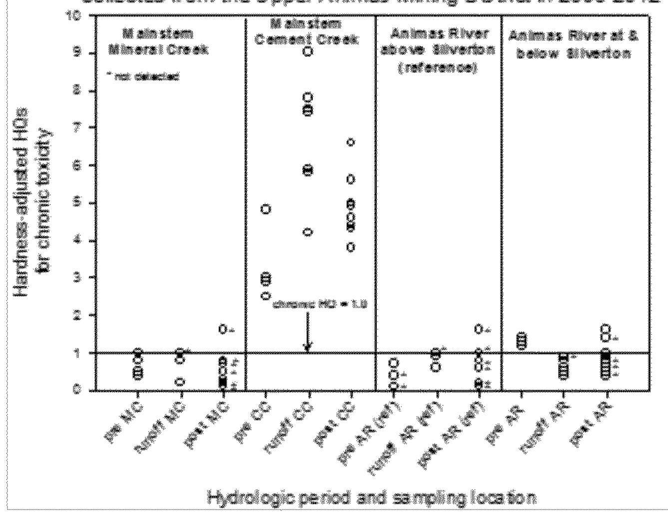


Figure 5.3: Hardness-adjusted dissolved lead HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the upper Animas Mining District in 2009-2012

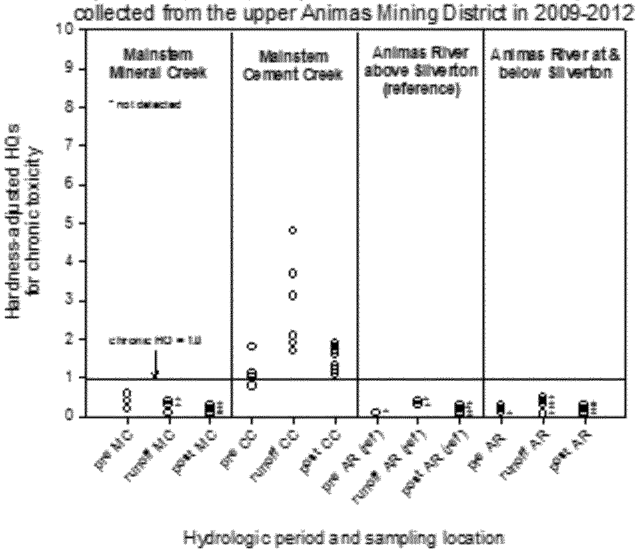


Figure 5.4: Hardness-adjusted dissolved manganese HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining District in 2009-2012

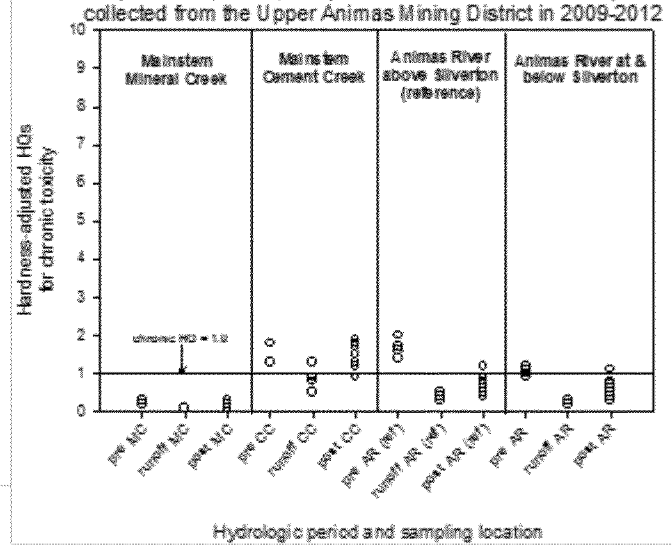


Figure 5.5: Hardness-adjusted dissolved zinc HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining District in 2009-2012

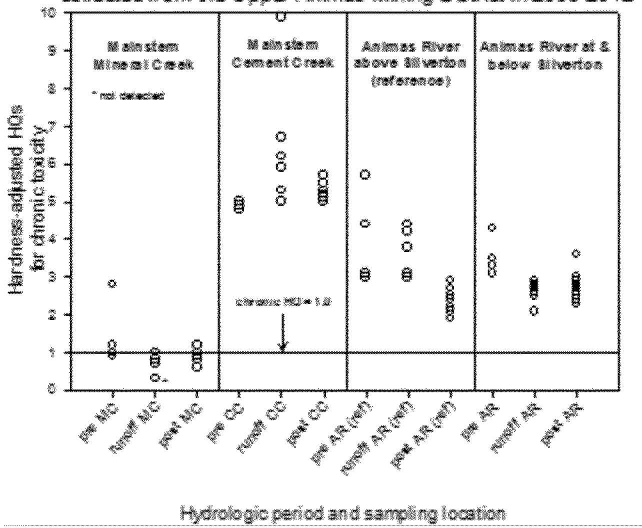


Figure 5.6: Dissolved aluminum HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining District in 2009-2012

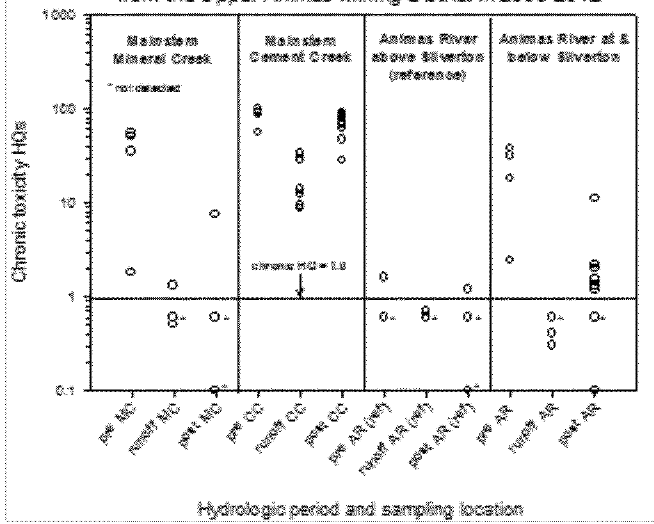


Figure 5.7: Dissolved iron HQs in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining Districy in 2009-2012

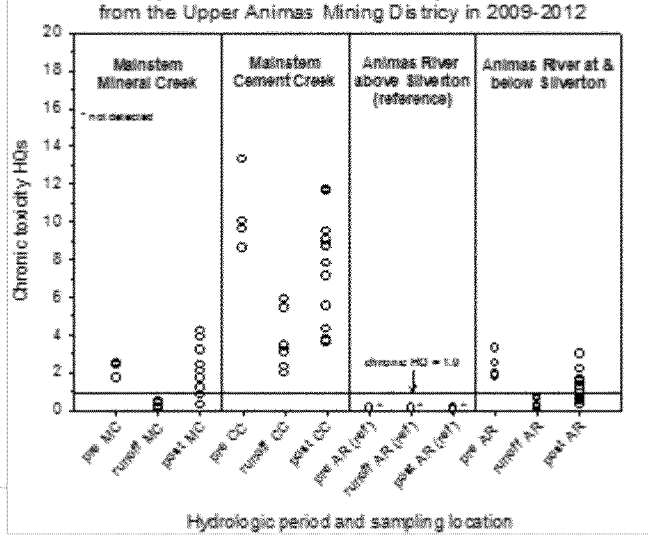


Figure 5.8: pH in pre-runoff, runoff, and post-runoff surface water samples collected from the Upper Animas Mining District in 2009-2012

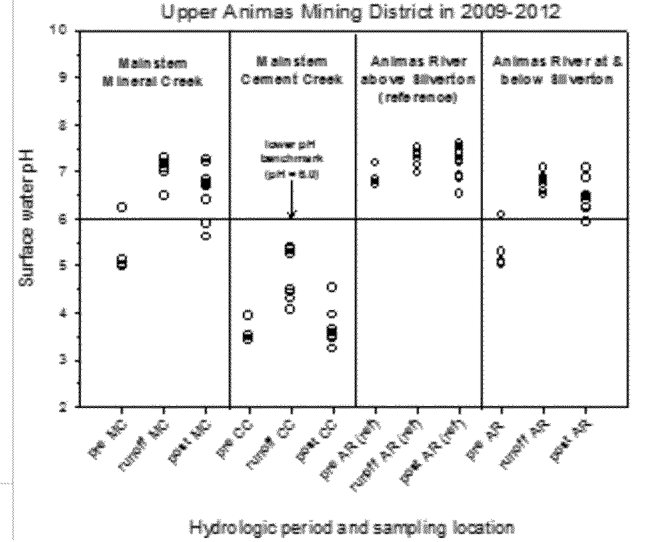


Figure 5.9: No-effect HQs for aquatic insectivorous birds feeding in the Animas River at and below Silverton (max. exposures)

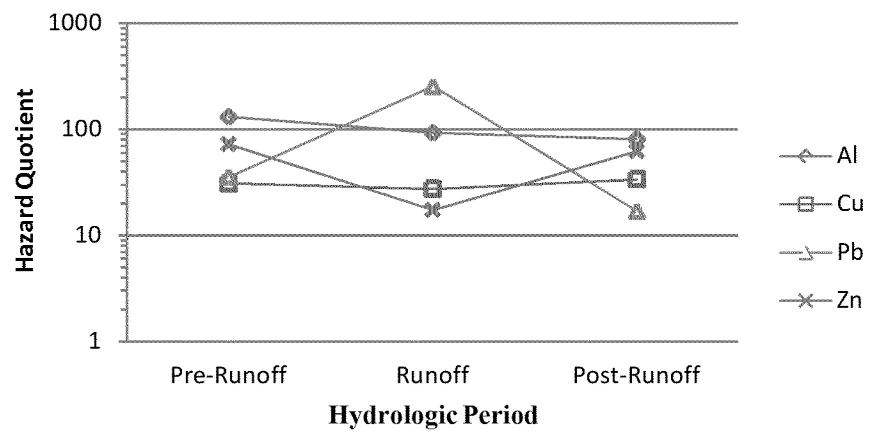


Figure 5.10: No-effect HQs for aquatic omnivorous birds feeding in the Animas River at and below Silverton (max. exposures)

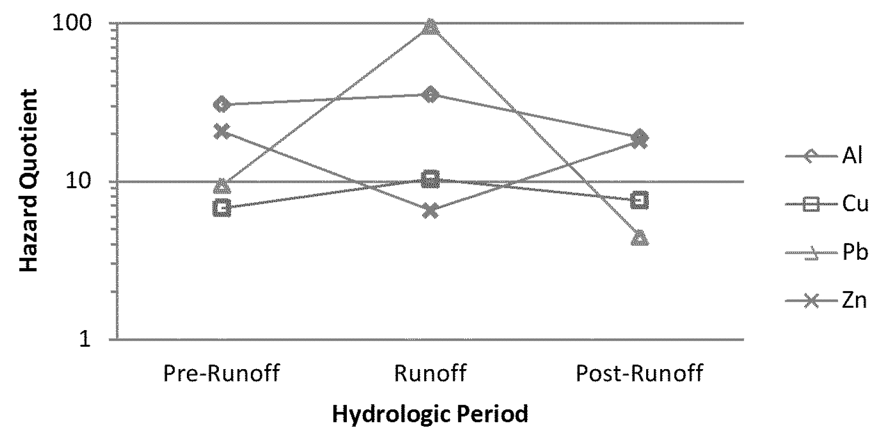


Figure 5.11: No-effect HQs for piscivorous birds feeding in the Animas River at and below Silverton (max. exposures)

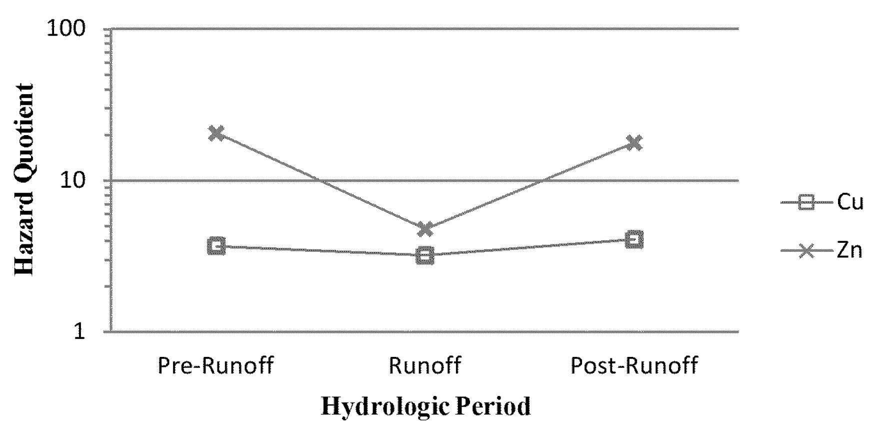
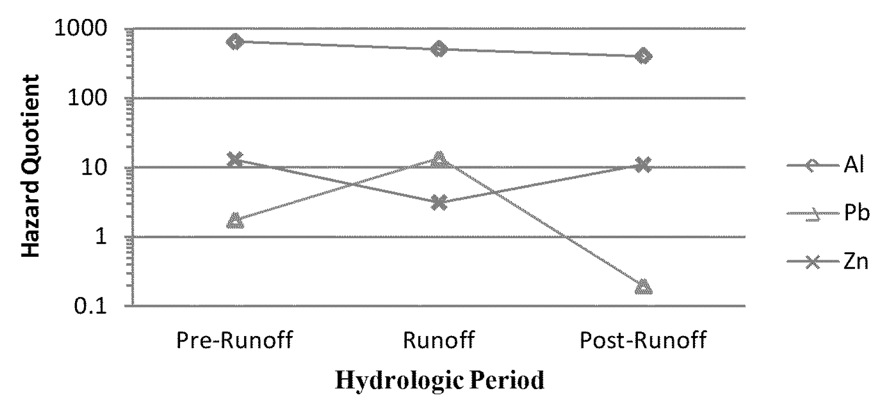


Figure 5.12: No-effect HQs for aquatic herbivorous mammals feeding in the Animas River at and below Silverton (max. exposures)



TABLES

Table 2.1
Summary of Data Parameters by Sampling Location and Sampling Period
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Sample Location	Location Description	Surface Water									Sediment
		Pre-Runoff Period[a]			Runoff Period[b]			Post-Runoff Period[c]			Runoff Period
		pH	Dissolved Metals	Total Metals	pH	Dissolved Metals	Total Metals	pH	Dissolved Metals	Total Metals	Total Metals
CEMENT CREEK											
CC21	across from the historic mining town of Gladstone	--	--	--	√	√	√	--	--	--	--
CC41	halfway between Gladstone & Silverton	--	--	--	√	√	√	--	--	--	--
CC48	just upstream of confluence w/ Animas R.	√	√	√	√	√	√	√	√	√	--
MINERAL CREEK											
M34	just upstream of confluence w/ Animas R.	√	√	√	√	√	√	√	√	√	--
ANIMAS RIVER											
A68	reference (above Silverton)	√	√	√	√	√	√	√	√	√	√
A72	about 0.5 miles below confluence w/ Mineral Cr.	√	√	√	√	√	√	√	√	√	√
OPP 1 to 10[d]	below confluence w/ Mineral Cr.	--	--	--	√	√	√	--	--	--	√

√ = at least one sample was collected for analysis
-- = no samples were collected for analysis

[a] the pre-runoff period consists of February to April 2010 and 2011
[b] the runoff period consists of May and June 2009 to 2012
[c] the post runoff period consists of July to November 2009 to 2011
[d] "opportunity samples" collected in May 2012

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 3.1
Summary of Surface Water and Sediment Screening Benchmarks
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

metals	surface water (µg/L)			sediment (mg/kg)		
	CDPHE (2009)	USEPA (2009)	Buchman (2008)	MacDonald *et al.* (2000)	Ingersoll *et al.* (1996)	Long *et al.* (1995)
Aluminum	87	87	87	NA	26,000	NA
Antimony	NA	NA	30	NA	NA	NA
Arsenic	150	150	190	9.8	11	8.2
Beryllium	NA	NA	0.66	NA	NA	NA
Cadmium	$(1.101672-[\ln(\text{hardness}) \times (0.041838)] \times e^{0.7998[\ln(\text{hardness})]-4.4451}$ (trout)	eqn	0.25	0.99	0.58	1.2
Chromium	$e^{(0.819[\ln(\text{hardness})]+0.5340)}$	eqn	74	43.4	36	81
Copper	$e^{(0.8545[\ln(\text{hardness})]-1.7428)}$	eqn	9	31.6	28	34
Iron	1,000.00	1,000	1,000	NA	190,000	NA
Lead	$(1.46203-[(\ln(\text{hardness}) \times (0.145712)]) \times e^{(1.273[\ln(\text{hardness})]-4.705)}$	eqn	3	35.8	37	46.7
Manganese	$e^{(0.3331[\ln(\text{hardness})]+5.8743)}$	eqn	80	NA	630	NA
Mercury	0.01	0.77	0.77	0.18	NA	0.15
Nickel	$e^{(0.846[\ln(\text{hardness})]+0.0554)}$	52	52	22.7	20	20.9
Selenium	4.6	5	5.0 total	NA	NA	NA
Silver	$e^{(1.72[\ln(\text{hardness})]-10.51)}$ (trout)	eqn	0.36	NA	NA	1.0
Strontium	NA	NA	1,500	NA	NA	NA
Thallium	15	NA	0.03	NA	NA	NA
Vanadium	NA	NA	19	NA	NA	NA
Zinc	$0.986 \times e^{(0.8525[\ln(\text{hardness})]+0.9109)}$	eqn	120	121	98	150

shading identifies the screening benchmarks selected for use in the SLERA

created by: SJP (7/15/12)
reviewed by: SMT (8/20/12)

Table 3.2
No-Effect TRVs for mammals
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Analyte	Eco-SSL TRVs[a]	1996 toxicological benchmarks for wildlife[b]	1999 mammal TRVs[c]
Aluminum	--	1.93	1.93
Antimony	0.059	0.125	0.066
Arsenic	1.04	0.126	1.25
Beryllium	0.532	0.66	0.66
Cadmium	0.77	1	0.0252
Chromium III	2.4	2737	--
Chromium VI	9.24	3.28	3.5
Copper	5.6	11.7	12
Iron	--	--	--
Lead	4.7	8	0.0375
Manganese	51.5	88	--
Mercury (inorganic)	--	1	1.01
Nickel	1.7	40	50
Selenium	0.143	0.2	0.076
Silver	6.02	--	0.375
Strontium	--	263	--
Thallium	--	0.0074	0.0131
Vanadium	4.16	0.21	--
Zinc	75.4	160	--

Footnotes:
All units are in mg/kg bw-day
Shading identifies TRVs selected for use in the SLERA
[a] USEPA Eco SSL reports (http://www.epa.gov/ecotox/ecossl), as follows:
EPA, 2005. Ecological soil screening levels for antimony. Interim final. OSWER Directive 9285.7-61.
EPA, 2005. Ecological soil screening levels for arsenic. Interim final. OSWER Directive 9285.7-62.
EPA, 2005. Ecological soil screening levels for beryllium. Interim final. OSWER Directive 9285.7-64.
EPA, 2005. Ecological soil screening levels for cadmium. Interim final. OSWER Directive 9285.7-65.
EPA, 2008. Ecological soil screening levels for chromium. Interim final. OSWER Directive 9285.7-66.
EPA, 2007. Ecological soil screening levels for copper. Interim final. OSWER Directive 9285.7-68.
EPA, 2005. Ecological soil screening levels for lead. Interim final. OSWER Directive 9285.7-70.
EPA, 2007. Ecological soil screening levels for manganese. Interim final. OSWER Directive 9285.7-71.
EPA, 2007. Ecological soil screening levels for nickel. Interim final. OSWER Directive 9285.7-76.
EPA, 2007. Ecological soil screening levels for selenium. Interim final. OSWER Directive 9285.7-72.
EPA, 2006. Ecological soil screening levels for silver. Interim final. OSWER Directive 9285.7-77.
EPA, 2005. Ecological soil screening levels for vanadium. Interim final. OSWER Directive 9285.7-75.
EPA, 2007. Ecological soil screening levels for zinc. Interim final. OSWER Directive 9285.7-73.
[b] Sample et al., 1996, Toxicological Benchmarks for Wildlife: 1996 Revision, ES/ER/TM-86/R3, http://www.esd.ornl.gov/programs/ecorisk/documents/tm86r3.pdf (values represent the test species)

[c] EPA, 1999, Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities Peer Review Draft. November 1999, http://www.epa.gov/osw/hazard/tsd/td/combust/ecorisk.htm
-- not available
EcoSSL – ecological soil screening level
TRV – toxicity reference value

created by: SJP (7/15/12)
reviewed by: SMT (8/20/12)

Table 3.3
No-Effect TRVs for birds
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Analyte	Eco-SSL TRVs[a]	1996 toxicological benchmarks for wildlife[b]	1999 bird TRVs[c]
Aluminum	--	109.7	100
Antimony	--	--	--
Arsenic	2.24	5.14	2.46
Beryllium	--	--	--
Cadmium	1.47	1.45	1.45
Chromium III	2.66	1	--
Chromium VI	--	--	1
Copper	4.05	47	46.97
Iron	--	--	--
Lead	1.63	1.13	0.025
Manganese	179	997	--
Mercury	--	0.45	3.25
Nickel	6.71	77.4	65
Selenium	0.29	0.5	0.5
Silver	2.02	--	178
Strontium	--	--	--
Thallium	--	--	0.35
Vanadium	0.344	11.4	--
Zinc	66.1	14.5	130.9

Footnotes:

All units are mg/kg bw-day

Shading identifies TRVs selected for use in the SLERA

[a] EPA Eco SSL reports (http://www.epa.gov/ecotox/ecossl), as follows:

EPA, 2005. Ecological soil screening levels for arsenic. Interim final. OSWER Directive 9285.7-62.
EPA, 2005. Ecological soil screening levels for cadmium. Interim final. OSWER Directive 9285.7-65.
EPA, 2008. Ecological soil screening levels for chromium. Interim final. OSWER Directive 9285.7-66.
EPA, 2007. Ecological soil screening levels for copper. Interim final. OSWER Directive 9285.7-68.
EPA, 2005. Ecological soil screening levels for lead. Interim final. OSWER Directive 9285.7-70.
EPA, 2007. Ecological soil screening levels for manganese. Interim final. OSWER Directive 9285.7-71.
EPA, 2007. Ecological soil screening levels for nickel. Interim final. OSWER Directive 9285.7-76.
EPA, 2007. Ecological soil screening levels for selenium. Interim final. OSWER Directive 9285.7-72.
EPA, 2006. Ecological soil screening levels for silver. Interim final. OSWER Directive 9285.7-77.
EPA, 2005. Ecological soil screening levels for vanadium. Interim final. OSWER Directive 9285.7-75.
EPA, 2007. Ecological soil screening levels for zinc. Interim final. OSWER Directive 9285.7-73.

[b] Sample et al., 1996, Toxicological Benchmarks for Wildlife: 1996 Revision, ES/ER/TM-86/R3, http://www.esd.ornl.gov/programs/ecorisk/documents/tm86r3.pdf(values represent the test species)

[c] EPA, 1999, Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities Peer Review Draft. November 1999, http://www.epa.gov/osw/hazard/tsd/td/combust/ecorisk.htm

-- not available
EcoSSL – ecological soil screening level
TRV – toxicity reference value

created by: SJP (7/15/12)
reviewed by: SMT (8/20/12)

Table 3.4
Selection of Surface Water COPECs for Community-Level Receptors
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Compound	Frequency of Detection	Minimum Detect (mg/L)	Flag	Maximum Detect (mg/L)[a]	Flag	Location of Maximum Detect	Conc. used for Screening	Benchmark (ug/L)[b]	Minimum Hardness (mg/L)[c]	Hardness-Adjusted Benchmark (ug/L)[d]	Bench-mark Source	Hazard Quotient[e]	COPEC?	Reason Code
pH	72/72	3.24		7.28		CC48	3.24	6.00	--	--		> 1[f]	**Yes**	a
Aluminum	50/72	25	U	8450		CC48	8450	87	--	--	1	**97.1**	**Yes**	a
Arsenic	1/72	0.5	J	4.0	U	multiple	4.0	150	--	--	1	0.03	No	b,c
Beryllium	10/72	0.2	U	2.0	U	multiple	2.0	0.66	--	--	2	**3.0**	**Yes**	a
Cadmium	71/72	0.2		7.0		CC48	7.0	--	45	0.23	1	**30.3**	**Yes**	a
Chromium	0/72	0.5	U	5.0	U	multiple	5.0	--	45	39	1	0.1	No	b,c
Copper	54/72	1.7		221		CC48	221	--	45	4.5	1	**48.8**	**Yes**	a
Iron	70/72	10	U	13300		CC48	13300	1000	--	--	1	**13.3**	**Yes**	a
Lead	30/72	0.1	J	21.4		CC48	21.4	--	45	1.0	1	**20.5**	**Yes**	a
Manganese	72/72	84.9		5290		CC48	5290	--	45	1264	1	**4.2**	**Yes**	a
Nickel	46/72	0.6	J	19.4		CC48	19.4	--	45	26	1	0.7	No	b
Selenium	0/72	0.2	U	1.0	U	multiple	1.0	4.6	--	--	1	0.2	No	b,c
Silver	2/72	0.1	U	0.6		M34	0.6	--	45	0.019	1	31.6	**Yes**	a
Zinc	71 / 72	48.1		2890		CC48	2890	--	45	63	1	**45.9**	**Yes**	a

Notes:

[a] These values represent the maximum detected concentrations (except for pH which represents the lowest reported value) measured between May 2009 and May 2012 at the SLERA sampling locations in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River

[b] These benchmarks are not sensitive to surface water hardness

[c] This hardness was the lowest value measured between May 2009 and May 2012 at the sampling locations in mainstem Cement Creek, mainstem Mineral Creek, and the Animas River

[d] The formulae used to adjust the benchmarks to the minimum hardness were obtained from CDPHE, 2009 (see "benchmark sources" below)

[e] the hazard quotient is calculated by dividing a screening concentration by its benchmark

[f] pH values are logarithmic and cannot be used to calculate an HQ because the HQ approach assumes linearity

Reason codes:

a = the maximum concentration exceeds its chronic surface water benchmark
b = the maximum concentration falls below the chronic surface water benchmark
c = frequency of detection < 5%

Benchmark sources:

1 = Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p.
2 = Buchman, M.F. 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle, WA. Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, 34 pp

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 3.5
Selection of sediment COPCs for benthic invertebrates
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Metals	Frequency of Detection	Minimum Detect (mg/kg)	Flag[a]	Maximum Detect (mg/kg)[b]	Flag	Concentration used for Screening	Benchmark (mg/kg)	Bench-mark Source	Hazard Quotient[c]	COPEC?	Reason Code
Aluminum	3/3	12400	D	18600	D	18600	26000	2	0.7	No	b
Arsenic	3/3	37.9	D	46.2	D	46.2	9.8	1	4.7	**Yes**	a
Beryllium	3/3	2.0	D	2.2	D	2.2	NA	--	--	**Yes**	c
Cadmium	3/3	2.8	D	8.0	D	8.0	0.99	1	8.1	**Yes**	a
Chromium	3/3	5.2	D	6.0	D	6.0	43.4	1	0.1	No	b
Copper	3/3	153	D	370	D	370	31.6	1	11.7	**Yes**	a
Iron	3/3	58400	D	87800	D	87800	190000	2	0.5	No	b
Lead	3/3	582	D	948	D	948	35.8	1	26.5	**Yes**	a
Manganese	3/3	2810	D	7070	D	7070	630	2	11.2	**Yes**	a
Mercury	3/3	0.072	D	0.145	D	0.145	0.18	1	0.8	No	b
Nickel	3/3	6.4	D	11.8	D	11.8	22.7	1	0.5	No	b
Selenium	3/3	1.9	D	2.3	D	2.3	NA	--	--	**Yes**	c
Silver	3/3	1.9	D	5.0	D	5.0	1.0	3	5.0	**Yes**	a
Zinc	3/3	753	D	2240	D	2240	121	1	18.5	**Yes**	a

Notes:

[a] D = diluted

[b] These values represent the maximum detected sediment concentrations measured in May 2012 in the Animas River below the confluence with mainstem Cement Creek

[c] The hazard quotient is calculated by dividing a screening concentration by its benchmark

Reason codes:
a = the maximum concentration exceeds the sediment screening benchmark
b = the maximum concentration falls below the sediment screening benchmark
c = no benchmark available

Benchmark sources:
1 = MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.
2 = Ingersoll, C.G., P.S. Haverland, E.L. Brunson, R.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount and R.G. Fox, 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. International Association of Great Lakes Research. 22: 602-623.
3 = Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects with ranges of chemical concentrations in marine and estuarine sediments. Environ. Manag. 19:81-97.

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 3.6
Surface Water and Sediment COPECs for use in Food Chain Modeling
Animas River at and below Silverton
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Wildlife COPEC	Surface water (µg/L)[a]			Sediment (mg/kg)		
	pre-runoff period	runoff period	post-runoff period	pre-runoff period	runoff period	post-runoff period
aluminum	4440	3060	2750	--	18600	--
arsenic	2.0[b]	5.0	2.0[b]	--	46.2	--
beryllium	ND	ND	ND	--	2.16	--
cadmium	2.9	1.2	2.7	--	8.0	--
chromium	ND	ND	ND	--	6.0	--
copper	42.0	36.1	46.7	--	370	--
iron	7710	5300	5490	--	87800	--
lead	14.7	99.8	7.0	--	948	--
manganese	3110	755	2470	--	7070	--
nickel	7.0	2.0[b]	6.3	--	11.8	--
selenium	1.0	1.25[b]	0.5[b]	--	2.3	--
silver	0.25[b]	1.25[b]	0.25[b]	--	5.0	--
zinc	1320	306	1140		2240	

[a] values shown represent total metal concentrations

[b] value shown is one half of the maximum detection limit

ND = not detected in any of the surface water samples

created by: SJP (8/2/12)

reviewed by: SMT (8/20/12)

Table 4.1
Maximum EPCs for the Surface Water COPECs in the Three Waterways
Screening-Level Ecological Risk Assessment
Animas River Mining District

Exposure Unit	Hydrologic Period	Sampling Location	pH[a]	Aluminum	Beryllium	Cadmium	Copper	Iron	Lead	Manganese	Silver	Zinc
Cement Creek	pre-runoff	CC48	3.42	8450	1.3	4.9	110	13300	14.3	5290	0.25	2600
	runoff	CC21	4.50	1190	1.0	4.8	92.2	3410	7.4	2410	0.25	1710
		CC41	4.06	2410	1.0	3.4	77.4	5880	12.9	1750	0.25	1230
		CC48	4.29	2890	1.0	2.1	72.0	5360	9.0	1770	0.25	614
	post-runoff	CC48	3.24	7850	1.2	7.0	221.0	11700	17.4	5270	0.25	2890
Mineral Creek	pre-runoff	M34	4.97	4700	0.5	2.0	12.3	2490	4.2	634	0.25	499
	runoff	M34	6.49	117	1.0	0.3	5.0	512	0.5	160	0.25	68.6
	post-runoff	M34	5.62	656	0.5	1.0	10.0	4160	0.5	592	0.25	317
Animas River at & below Silverton	pre-runoff	A72	5.04	3290	0.5	2.9	35.9	3250	2.7	2920	0.25	864
	runoff	A72	6.50	50	1.0	0.8	5.0	746	0.5	504	0.25	217
	post-runoff	A72	5.93	959	0.5	2.8	36.9	3020	0.5	2490	0.25	1120

All units (except for pH) are in ug/L

Note: The concentrations for metals with hardness-dependent toxicity are not necessarily the maximum values from Appendix 1, but instead represent the concentrations with the highest hardness-adjusted HQs summarized in Appendix 3

[a] the values shown represent minimum measured pHs

created by: SJP (8/2/12)

reviewed by: SMT (8/20/12)

Table 4.2
Maximum EPCs for the sediment COPECs in the Animas River at and below Silverton
Screening-Level Ecological Risk Assessment
Animas River Mining District

Metals	Maximum Detect (mg/Kg)
Aluminum	18600
Arsenic	46.2
Beryllium	2.2
Cadmium	8.0
Chromium	6.0
Copper	370
Iron	87800
Lead	948
Manganese	7070
Nickel	11.8
Selenium	2.3
Silver	5.0
Zinc	2240

created by: SJP (8/2/12)

reviewed by: SMT (8/20/12)

Table 4.3
Maximum Surface Water and Sediment EPCs for Wildlife Receptors
Animas River at and below Silverton
Screening-Level Ecological Risk Assessment
Animas River Mining District

Wildlife COPEC	Surface water (µg/L)[a]			Sediment (mg/kg)		
	pre-runoff season	runoff season	post-runoff season	pre-runoff season	runoff season	post-runoff season
aluminum	4440	3060	2750	--	18600	--
arsenic	2.0[b]	5.0	2.0[b]	--	46.2	--
beryllium	ND	ND	ND	--	2.16	--
cadmium	2.9	1.2	2.7	--	8.0	--
chromium	ND	ND	ND	--	6.0	--
copper	42.0	36.1	46.7	--	370	--
iron	7710	5300	5490	--	87800	--
lead	14.7	99.8	7.0	--	948	--
manganese	3110	755	2470	--	7070	--
nickel	7.0	2.0[b]	6.3	--	11.8	--
selenium	1.0	1.25[b]	0.5[b]	--	2.3	--
silver	0.25[b]	1.25[b]	0.25[b]	--	5.0	--
zinc	1320	306	1140		2240	

[a] values shown represent total metal concentrations
[b] value shown is one half of the maximum detection limit

ND = not detected in any of the surface water samples

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 4.4
EDD formulas for the targeted wildlife receptors
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Avian insectivore - American dipper						
estimated daily dose (EDD$_x$)	=	**aquatic insect exposure** FIR*FC$_{insect}$*PDF*AUF	+	**surface water exposure** WIR*WC$_x$*AUF	+	**sediment exposure** SIR*SC$_x$*AUF
mg/kg BW-day		mg/kg BW-day		L/kg BW-day		mg/kg BW-day
Mammalian herbivore - muskrat						
estimated daily dose (EDD$_x$)	=	**aquatic plant exposure** FIR*FC$_{plant}$*PDF*AUF	+	**surface water exposure** WIR*WC$_x$*AUF	+	**sediment exposure** SIR*SC$_x$*AUF
mg/kg BW-day		mg/kg BW-day		L/kg BW-day		mg/kg BW-day
Avian piscivore - belted kingfisher						
estimated daily dose (EDD$_x$)	=	**fish exposure** FIR*FC$_{fish}$*PDF*AUF	+	**surface water exposure** WIR*WC$_x$*AUF		
mg/kg BW-day		mg/kg BW-day		L/kg BW-day		
Avian omnivore - mallard [#]						
estimated daily dose (EDD$_x$)	=	**invertebrate and plant exposure**[#] FIR[(FC$_{invert}$*PDF)+(FC$_{plant}$*PDF)]*AUF	+	**surface water exposure** WIR*WC$_x$*AUF	+	**sediment exposure** SIR*SC$_x$*AUF
mg/kg BW-day		mg/kg BW-day		L/kg BW-day		mg/kg BW-day

[#] The mallard is assumed to feed 100% on a protein-rich diet of aquatic invertebrates in the May-June "runoff" period to prepare for egg laying (USEPA, 1993), but an equal diet of aquatic invertebrates (50%) and plants (50%) in the "pre-runoff" and "post-runoff" periods.

FC$_{xi}$ =WC$_x$*BCF$_x$*BAV

Where:
- EDD$_x$ = estimated daily dose of COPEC "x" (mg COPEC/kg BW-day)
- FIR = food ingestion rate (kg/kg BW-day)
- FC$_{xi}$ = concentration of COPEC "x" in food item "i" (mg/kg)
- PDF = proportion of diet composed of food type "i" (unitless)
- WIR = water ingestion rate (L/day)
- WC$_x$ = concentration of COPEC "x" in surface water (mg/L)
- SIR = sediment ingestion rate (kg/day)
- SC$_x$ = concentration of COPEC"x" in sediment (mg/kg [calculated as a receptor-specific fraction of the FIR])
- BCF$_x$ = bioconcentration factor of COPEC "x"
- BW = body weight (kg)
- AUF = area use factor (unitless; assumed 1.0)
- BAV = bioavailability (unitless; assumed 1.0)

created by: SJP (7/15/12)
reviewed by: SMT (8/20/12)

Table 4.5
Exposure Parameters for the Four Wildlife Receptors used in Food Chain Modeling
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

wildlife species	body weight (kg)	ingestion rates: food (kg/kg BW-day, ww)	ingestion rates: water (L/kg BW-day)	ingestion rates: sediment (kg/kg BW-day, dw)	dietary composition (%): aquatic invert.	dietary composition (%): fish	dietary composition (%): aquatic plants	home range
Aquatic Insectivorous Birds								
American dipper (*Cinclus mexicanus*)	0.0565[c]	0.796[a]	0.152[b]	0.01592[l]	100[h]	--	--	759 m (along a water course)
Aquatic Herbivorous Mammals								
muskrat (*Ondatra zibethicus*)	1.17[d]	0.34[e]	0.975[e]	0.0068[l]	--	--	100[h]	0.13 hectares
Piscivorous Birds								
belted kingfisher (*Ceryle alcyon*)	0.147[e]	0.5[e]	0.111[e]	--[m]	--	100[h]	--	2.25 km
Omnivorous Birds								
mallard (*Anas platyrhynchos*)	1.162[e]	0.31[a]	0.056[e]	0.00124[k]	100[i] 50[j]	--	50[j]	111 hectares

[a] Calculated using IR_{food} (kg dw/day) = 0.0582*(BW, kg)$^{0.651}$; Adjusted to wet weight assuming 80% moisture (Nagy, 1987 - as reported in US EPA, 1993)
[b] Calculated using IR_{water} (L/day)=0.059 (BW, kg)$^{0.67}$; [Calder (1981), Skadhauge (1975), Calder and Braun (1983) - as reported in US EPA, 1993]
[c] Ealey, D., 1977
[d] Silva and Downing, 1995
[e] EPA, 1993
[f] Sullivan, J., 1973
[g] Sample & Suter, 1994
[h] Conservative assumption
[i] Dietary consumption in the May-June "runoff" period is assumed to be 100% aquatic invertebrates as females prepare for egg production.
[j] Dietary consumption is assumed to be 50% aquatic invertebrates and 50% aquatic plants in the "pre-runoff" and "post-runoff" periods.
[k] Table 4-4 in EPA, 1993 (value represents 2% of food intake on a dry-weight basis, assuming 80% moisture content)
[l] best professional judgment (value represents 10% of food intake on a dry-weight basis, assuming 80% moisture content)
[m] best professional judgment (kingfisher catch fish from within the water column and are assumed not to ingest sediment)
BW - Body weight
ww - Wet weight

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 4.6
Screening-level BCFs used in Food Chain Modeling
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

Analyte	Water-to-Aquatic Invertebrates[a]	Water-to-Plants[b,d]	Water-to-Fish[c]
Aluminum	4066	833	2.7
Antimony	7	1475	40
Arsenic	73	293	114
Beryllium	45	141	62
Cadmium	3461	782	907
Chromium, total	3000	4406	19
Copper	3718	541	710
Iron	--	--	--
Lead	5059	1706	0.09
Manganese	--	--	--
Mercury (inorganic)	20184	24762	3530
Nickel	28	61	78
Selenium	1262	1845	129
Silver	298	10696	87.71
Strontium	--	--	--
Thallium	15000	15000	10000
Vanadium	--	--	--
Zinc	4578	2175	2059

Source: Appendix C in EPA, 1999. SLERA Protocol for Hazardous Waste Combustion Facilities. EPA/530/D-99/001A.

[a] - Table C-3: Water-to-Aquatic Invertebrate Bioconcentration Factors

[b] - Table C-4: Water-to-Algae Bioconcentration Factors

[c] - Table C-5: Water-to-Fish Bioconcentration Factors

[d] - Water-to-algae BCFs were used as a surrogate for water-to-(vascular) plant because water-to- (vascular) plant BCFs were not available.
Note: The metal BCFs presented in the EPA(1999) were derived for use with the dissolved (filtered) fraction in surface water.
The SLERA report will multiply these BCFs with the total (unfiltered) faction instead as measure of added conservatism.

created by: SJP (7/15/12)

reviewed by: SMT (8/20/12)

Table 4.7
EDDs for the American Dipper Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

				Pre-Runoff Period						Runoff Period**							Post-Runoff Period					
	BCFs, BAVs, and AUFs			EPCs		Aquatic Invert. Conc. (mg/kg, wet wt.)	Estimated Daily Dose			EPCs		Aquatic Invert. Conc. (mg/kg, wet wt.)	Estimated Daily Dose				EPCs		Aquatic Invert. Conc. (mg/kg, wet wt.)	Estimated Daily Dose		
COPECs	Aquatic Invert. BCF#	BAV	AUF	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food} [1]	EDD_{water} [2]	EDD_{total} [4]	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food} [1]	EDD_{water} [2]	EDD_{sed} [3]	EDD_{total} [4]	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food} [1]	EDD_{water} [2]	EDD_{total} [4]
Metals, Total																						
Aluminum	4066	1.0	1.0	4.4	NA	18053	14370	0.67488	14371	3.1	18600	12442	9904	0.46512	296	10200	2.8	NA	11182	8900	0.418	8901
Arsenic	73.0	1.0	1.0	0.002	NA	0.146	0.116216	0.000304	0.11652	0.005	46.2	0.365	0.29054	0.00076	0.735504	1.0	0.002	NA	0.146	0.116216	0.000304	0.11652
Beryllium	45.0	1.0	1.0	0.0005	NA	0.0225	0.01791	0.000076	0.017986	0.001	2.2	0.045	0.03582	0.000152	0.034387	0.0703592	0.0005	NA	0.0225	0.01791	0.000076	0.017986
Cadmium	3461	1.0	1.0	0.0029	NA	10.0	8.0	0.0004408	8.0	0.0012	8.0	4.2	3.3	0.0001824	0.12736	3.4	0.0027	NA	9.3	7.4	0.0004104	7.4
Chromium	3000	1.0	1.0	0.0025	NA	7.5	6.0	0.00038	6.0	0.0025	6.0	7.5	6.0	0.00038	0.09552	6.1	0.0025	NA	7.5	6.0	0.00038	6.0
Copper	3718	1.0	1.0	0.042	NA	156	124	0.006384	124	0.0361	370	134	107	0.0054872	5.9	113	0.0467	NA	174	138	0.0070984	138
Iron	1.0	1.0	1.0	7.7	NA	7.7	6.1	1.2	7.3	5.3	87800	5.3	4.2	0.8056	1398	1403	5.5	NA	5.5	4.4	0.83448	5.2
Lead	5059	1.0	1.0	0.0147	NA	74.4	59.2	0.0022344	59.2	0.0998	948	505	402	0.0151696	15.1	417	0.007	NA	35.4	28.2	0.001064	28.2
Manganese	1.0	1.0	1.0	3.1	NA	3.1	2.5	0.47272	2.9	0.755	7070	0.755	0.60098	0.11476	113	113	2.5	NA	2.5	2.0	0.37544	2.3
Nickel	28.0	1.0	1.0	0.007	NA	0.196	0.156016	0.001064	0.15708	0.002	11.8	0.056	0.044576	0.000304	0.187856	0.232736	0.0063	NA	0.1764	0.1404144	0.0009576	0.141372
Selenium	1262	1.0	1.0	0.0005	NA	0.631	0.502276	0.000076	0.502352	0.00125	2.3	1.6	1.3	0.00019	0.036616	1.3	0.0005	NA	0.631	0.502276	0.000076	0.502352
Silver	298	1.0	1.0	0.00025	NA	0.0745	0.059302	0.000038	0.05934	0.00125	5.0	0.3725	0.29651	0.00019	0.0796	0.3763	0.00025	NA	0.0745	0.059302	0.000038	0.05934
Zinc	4578	1.0	1.0	1.3	NA	6043	4810	0.20064	4810	0.306	2240	1401	1115	0.046512	35.7	1151	1.1	NA	5219	4154	0.17328	4154

** - Sediment data is available only for the Runoff period.
# - A default value of 1.0 was used when no BCF was available.
COPECs - Chemicals of Potential Ecological Concern
EPC - Exposure Point Concentration
EDD - Estimated Daily Dose
BCF - Bioconcentration Factor
AUF - Area Use Factor (unitless)
BAV - Bioavailability Adjustment Factor (unitless)
NA - Not available
NC - Not calculated
mg/L - milligrams per liter; mg/L = mg/kg
mg/kg, wet wt - milligrams per kilogram, wet weight
mg/kg bw-day - milligrams per kilogram of body weight per day
kg/kg BW-d - Kilograms per kilogram body weight per day
L/kg BW-d - Liters per kilogram body weight per day

EDD Equations
[1] $EDD_{food} = (IR_{food} \times C_{invert}) \times AUF \times BAV$
[2] $EDD_{water} = IR_{water} \times C_{water} \times AUF \times BAV$
[3] $EDD_{sed} = IR_{sed} \times C_{sed} \times AUF \times BAV$
[4] $EDD_{total} = EDD_{food} + EDD_{water} + EDD_{sed}$

Ingestion Rates (IR)

IR_{food}	0.796	kg/kg BW-day
IR_{water}	0.152	L/kg BW-day
IR_{sed}	0.01592	kg/kg BW-day

created by: MR (8/5/12)
reviewed by: SMT (8/20/12)

Table 4.8
EDDs for the Mallard Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	BCFs, BAVs, and AUFs				Pre-Runoff Period							Runoff Period**							Post-Runoff Period						
					EPCs		Aquatic Invert. Conc.* (mg/kg, wet wt.)	Aquatic Plants Conc.* (mg/kg, wet wt.)	Estimated Daily Dose			EPCs		Aquatic Invert. Conc.* (mg/kg, wet wt.)	Estimated Daily Dose				EPCs		Aquatic Invert. Conc.* (mg/kg, wet wt.)	Aquatic Plants Conc.* (mg/kg, wet wt.)	Estimated Daily Dose		
COPECs	Aquatic Invert. BCF#	Aquatic Plants BCF#	BAV	AUF	Surface Water (mg/L)	Sediment (mg/kg)			EDD_{food} [1]	EDD_{water} [2]	EDD_{total} [4]	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food} [1]	EDD_{water} [2]	EDD_{sed} [3]	EDD_{total} [4]	Surface Water (mg/L)	Sediment (mg/kg)			EDD_{food} [1]	EDD_{water} [2]	EDD_{total} [4]
Metals, Total																									
Aluminum	4066	833	1.0	1.0	4.4	NA	18053	3699	3371	0.24864	3372	3.1	18600	12442	3857	0.17136	23.1	3880	2.8	NA	11182	2291	2088	0.15400	2088
Arsenic	73.0	293	1.0	1.0	0.002	NA	0.146	0.586	0.11346	0.00011	0.114	0.005	46.2	0.365	0.11315	0.00028	0.057	0.171	0.002	NA	0.146	0.586	0.11346	0.00011	0.114
Beryllium	45.0	141	1.0	1.0	0.0005	NA	0.0225	0.0705	0.014415	0.00003	0.014	0.001	2.2	0.045	0.01395	0.00006	0.003	0.017	0.0005	NA	0.0225	0.071	0.014415	0.00003	0.014
Cadmium	3461	782	1.0	1.0	0.0029	NA	10.0	2.3	1.9	0.00016	1.9	0.0012	8.0	4.2	1.3	0.00007	0.010	1.3	0.0027	NA	9.3	2.1	1.8	0.00015	1.8
Chromium	3000	4406	1.0	1.0	0.0025	NA	7.5	11.0	2.9	0.00014	2.9	0.0025	6.0	7.5	2.3	0.00014	0.007	2.3	0.0025	NA	7.5	11.0	2.9	0.00014	2.9
Copper	3718	541	1.0	1.0	0.042	NA	156	22.7	27.7	0.00235	27.7	0.0361	370	134	41.6	0.00202	0.459	42.1	0.0467	NA	174	25.3	30.8	0.00262	30.8
Iron	1.0	1.0	1.0	1.0	7.7	NA	7.7	7.7	2.4	0.43176	2.8	5.3	87800	5.3	1.6	0.29680	109	111	5.5	NA	5.5	5.5	1.7	0.30744	2.0
Lead	5059	1706	1.0	1.0	0.0147	NA	74.4	25.1	15.4	0.00082	15.4	0.0998	948	505	157	0.00559	1.2	158	0.007	NA	35.4	11.9	7.3	0.00039	7.3
Manganese	1.0	1.0	1.0	1.0	3.1	NA	3.1	3.1	0.9641	0.17416	1.1	0.755	7070	0.755	0.23405	0.04228	8.8	9.0	2.5	NA	2.5	2.5	0.7657	0.13832	0.904
Nickel	28.0	61.0	1.0	1.0	0.007	NA	0.196	0.427	0.096565	0.00039	0.097	0.002	11.8	0.056	0.01736	0.00011	0.015	0.032	0.0063	NA	0.1764	0.384	0.086909	0.00035	0.087
Selenium	1262	1845	1.0	1.0	0.0005	NA	0.631	0.9225	0.240793	0.00003	0.241	0.00125	2.3	1.6	0.489025	0.00007	0.003	0.492	0.0005	NA	0.631	0.923	0.240793	0.00003	0.241
Silver	298	10696	1.0	1.0	0.00025	NA	0.0745	2.7	0.426018	0.00001	0.426	0.00125	5.0	0.3725	0.115475	0.00007	0.006	0.122	0.00025	NA	0.0745	2.7	0.426018	0.00001	0.426
Zinc	4578	2175	1.0	1.0	1.3	NA	6043	2871	1382	0.07392	1382	0.306	2240	1401	434	0.01714	2.8	437	1.1	NA	5219	2480	1193	0.06384	1193

* - The dietary composition is assumed to be 100% aquatic invertebrates during the May-June "runoff" period as females prepare for egg production. The dietary composition is assumed to be 50% aquatic invertebrates and 50% aquatic plants in the "pre-runoff" and "post-runoff" periods.
** - Sediment data is available only for the Runoff period.
A default value of 1.0 was used when no BCF was available.
COPECs - Chemicals of Potential Ecological Concern
EPC - Exposure Point Concentration
EDD - Estimated Daily Dose
BCF - Bioconcentration Factor
AUF - Area Use Factor (unitless)
BAV - Bioavailability Adjustment Factor (unitless)
NA - Not available
NC - Not calculated
PDF - Proportion of Diet Composition
mg/L - milligrams per liter; mg/L = mg/kg
mg/kg, wet wt - milligrams per kilogram, wet weight
mg/kg bw-day - milligrams per kilogram of body weight per day
kg/kg BW-d - Kilograms per kilogram body weight per day
L/kg BW-d - Liters per kilogram body weight per day

EDD Equations
[1] $EDD_{food} = IR_{food} \times \{(C_{invert} \times PDF) + (C_{plant} * PDF)\} \times AUF \times BAV$
[2] $EDD_{water} = IR_{water} \times C_{water} \times AUF \times BAV$
[3] $EDD_{sed} = IR_{sed} \times C_{sed} \times AUF \times BAV$
[4] $EDD_{total} = EDD_{food} + EDD_{water} + EDD_{sed}$

Ingestion Rates (IR)

IR_{food}	0.31	kg/kg BW-day	
IR_{water}	0.056	L/kg BW-day	
IR_{sed}	0.00124	kg/kg BW-day	
PDF	0.5	Accounts for 50% aquatic invertebrates and 50% aquatic plants in the pre- and post-runoff periods.	

created by: MR (8/5/12)
reviewed by: SMT (8/20/12)

Table 4.9
EDDs for the Belted Kingfisher Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

				Pre-Runoff Period						Runoff Period**						Post-Runoff Period					
	BCFs, BAVs, and AUFs			EPCs			Estimated Daily Dose			EPCs			Estimated Daily Dose			EPCs			Estimated Daily Dose		
COPECs	Fish BCF#	BAV	AUF	Surface Water (mg/L)	Sediment* (mg/kg)	Fish Conc. (mg/kg, wet wt.)	EDD_{food}[1]	EDD_{water}[2]	EDD_{total}[3]	Surface Water (mg/L)	Sediment* (mg/kg)	Fish Conc. (mg/kg, wet wt.)	EDD_{food}[1]	EDD_{water}[2]	EDD_{total}[3]	Surface Water (mg/L)	Sediment* (mg/kg)	Fish Conc. (mg/kg, wet wt.)	EDD_{food}[1]	EDD_{water}[2]	EDD_{total}[3]
Metals, Total																					
Aluminum	2.7	1.0	1.0	4.4	NA	12.0	6.0	0.49284	6.5	3.1	18600	8.3	4.1	0.33966	4.5	2.8	NA	7.4	3.7	0.30525	4.0
Arsenic	114	1.0	1.0	0.002	NA	0.228	0.114	0.00022	0.114	0.005	46.2	0.57	0.285	0.00056	0.286	0.002	NA	0.228	0.114	0.00022	0.114
Beryllium	62.0	1.0	1.0	0.0005	NA	0.031	0.0155	0.00006	0.016	0.001	2.2	0.062	0.031	0.00011	0.031	0.0005	NA	0.031	0.0155	0.00006	0.016
Cadmium	907	1.0	1.0	0.0029	NA	2.6	1.3	0.00032	1.3	0.0012	8.0	1.1	0.5442	0.00013	0.544	0.0027	NA	2.4	1.2	0.00030	1.2
Chromium	19.0	1.0	1.0	0.0025	NA	0.0475	0.02375	0.00028	0.02	0.0025	6.0	0.0475	0.02375	0.00028	0.024	0.0025	NA	0.0475	0.02375	0.00028	0.0
Copper	710	1.0	1.0	0.042	NA	29.8	14.9	0.00466	14.9	0.0361	370	25.6	12.8	0.00401	12.8	0.0467	NA	33.2	16.6	0.00518	16.6
Iron	1.0	1.0	1.0	7.7	NA	7.7	3.9	0.85581	4.7	5.3	87800	5.3	2.7	0.58830	3.2	5.5	NA	5.5	2.7	0.60939	3.4
Lead	0.09	1.0	1.0	0.0147	NA	0.001323	0.0006615	0.00163	0.0	0.0998	948	0.008982	0.004491	0.01108	0.016	0.007	NA	0.00063	0.000315	0.00078	0.00
Manganese	1.0	1.0	1.0	3.1	NA	3.1	1.6	0.34521	1.9	0.755	7070	0.755	0.3775	0.08381	0.461	2.5	NA	2.5	1.2	0.27417	1.5
Nickel	78.0	1.0	1.0	0.007	NA	0.546	0.273	0.00078	0.274	0.002	11.8	0.156	0.078	0.00022	0.078	0.0063	NA	0.4914	0.2457	0.00070	0.246
Selenium	129	1.0	1.0	0.0005	NA	0.0645	0.03225	0.00006	0.032	0.00125	2.3	0.16125	0.080625	0.00014	0.081	0.0005	NA	0.0645	0.03225	0.00006	0.032
Silver	87.7	1.0	1.0	0.00025	NA	0.0219275	0.0109638	0.00003	0.011	0.00125	5.0	0.1096375	0.05481875	0.00014	0.055	0.00025	NA	0.0219275	0.0109638	0.00003	0.011
Zinc	2059	1.0	1.0	1.3	NA	2718	1359	0.14652	1359	0.306	2240	630	315	0.03397	315	1.1	NA	2347	1174	0.12654	1174

* - Sediment data included in the table where applicable, even though the kingfisher catches fish from within the water column and was not assumed to ingest sediment. Thus, an EDD is not calculated for sediment and is not incorporated into the total EDD.

** - Sediment data is available only for the Runoff period.

A default value of 1.0 was used when no BCF was available.

COPECs - Chemicals of Potential Ecological Concern

EPC - Exposure Point Concentration

EDD - Estimated Daily Dose

BCF - Bioconcentration Factor

AUF - Area Use Factor (unitless)

BAV - Bioavailability Adjustment Factor (unitless)

NA - Not available

NC - Not calculated

PDF - Proportion of Diet Composition

mg/L - milligrams per liter; mg/L = mg/kg

mg/kg, wet wt - milligrams per kilogram, wet weight

mg/kg bw-day - milligrams per kilogram of body weight per day

kg/kg BW-d - Kilograms per kilogram body weight per day

L/kg BW-d - Liters per kilogram body weight per day

EDD Equations

[1] $EDD_{food} = (IR_{food} \times C_{fish}) \times AUF \times BAV$

[2] $EDD_{water} = IR_{water} \times C_{water} \times AUF$

[3] $EDD_{total} = EDD_{food} + EDD_{water}$

Ingestion Rates (IR)

IR_{food}	0.5	kg/kg BW-day
IR_{water}	0.111	L/kg BW-day

created by: MR (8/5/12)

reviewed by: SMT (8/20/12)

Table 4.10
EDDs for the Muskrat Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

COPECs	BCFs, BAVs, and AUFs			Pre-Runoff Period						Runoff Period**							Post-Runoff Period					
				EPCs		Aquatic Plants Conc. (mg/kg, wet wt.)	Estimated Daily Dose			EPCs		Aquatic Plants Conc. (mg/kg, wet wt.)	Estimated Daily Dose				EPCs		Aquatic Plants Conc. (mg/kg, wet wt.)	Estimated Daily Dose		
	Aquatic Plants BCF#	BAV	AUF	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food}[1]	EDD_{water}[2]	EDD_{total}[4]	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food}[1]	EDD_{water}[2]	EDD_{sed}[3]	EDD_{total}[4]	Surface Water (mg/L)	Sediment (mg/kg)		EDD_{food}[1]	EDD_{water}[2]	EDD_{total}[4]
Metals, Total																						
Aluminum	833	1.0	1.0	4.4	NA	3699	1257	4.3	1262	3.1	18600	2549	867	3.0	126	996	2.8	NA	2291	779	2.7	782
Arsenic	293	1.0	1.0	0.002	NA	0.586	0.19924	0.00195	0.201	0.005	46.2	1.5	0.4981	0.00488	0.314	0.817	0.002	NA	0.586	0.19924	0.00195	0.201
Beryllium	141	1.0	1.0	0.0005	NA	0.0705	0.02397	0.00049	0.024	0.001	2.2	0.141	0.04794	0.00098	0.015	0.064	0.0005	NA	0.0705	0.02397	0.00049	0.024
Cadmium	782	1.0	1.0	0.0029	NA	2.3	0.771052	0.00283	0.774	0.0012	8.0	0.9384	0.319056	0.00117	0.054	0.375	0.0027	NA	2.1	0.717876	0.00263	0.721
Chromium	4406	1.0	1.0	0.0025	NA	11.0	3.7	0.00244	3.7	0.0025	6.0	11.0	3.7	0.00244	0.041	3.8	0.0025	NA	11.0	3.7	0.00244	3.7
Copper	541	1.0	1.0	0.042	NA	22.7	7.7	0.04095	7.8	0.0361	370	19.5	6.6	0.03520	2.5	9.2	0.0467	NA	25.3	8.6	0.04553	8.6
Iron	1.0	1.0	1.0	7.7	NA	7.7	2.6	7.5	10.1	5.3	87800	5.3	1.8	5.2	597	604	5.5	NA	5.5	1.9	5.4	7.2
Lead	1706	1.0	1.0	0.0147	NA	25.1	8.5	0.01433	8.5	0.0998	948	170	57.9	0.09731	6.4	64.4	0.007	NA	11.9	4.1	0.00683	4.1
Manganese	1.0	1.0	1.0	3.1	NA	3.1	1.1	3.0	4.1	0.755	7070	0.755	0.2567	0.73613	48.1	49.1	2.5	NA	2.5	0.8398	2.4	3.2
Nickel	61.0	1.0	1.0	0.007	NA	0.427	0.14518	0.00683	0.152	0.002	11.8	0.122	0.04148	0.00195	0.080	0.124	0.0063	NA	0.3843	0.130662	0.00614	0.137
Selenium	1845	1.0	1.0	0.0005	NA	0.9225	0.31365	0.00049	0.314	0.00125	2.3	2.3	0.784125	0.00122	0.016	0.801	0.0005	NA	0.9225	0.31365	0.00049	0.314
Silver	10696	1.0	1.0	0.00025	NA	2.7	0.90916	0.00024	0.909	0.00125	5.0	13.4	4.5	0.00122	0.034	4.6	0.00025	NA	2.7	0.90916	0.00024	0.909
Zinc	2175	1.0	1.0	1.3	NA	2871	976	1.3	977	0.306	2240	666	226	0.29835	15.2	242	1.1	NA	2480	843	1.1	844

** - Sedimentdata is availableonly for the Runoffperiod.
A default value of 1.0 was used when no BCF was available.
COPECs - Chemicals of Potential Ecological Concern
EPC - Exposure Point Concentration
EDD - Estimated Daily Dose
BCF - Bioconcentration Factor
AUF - Area Use Factor (unitless)
BAV - Bioavailability Adjustment Factor (unitless)
NA - Not available
NC - Not calculated
PDF - Proportion of Diet Composition
mg/L - milligrams per liter; mg/L = mg/kg
mg/kg, wet wt - milligrams per kilogram, wet weight
mg/kg bw-day - milligramsper kilogramof body weight per day
kg/kg BW-d - Kilogramsper kilogrambody weight per day
L/kg BW-d - Liters per kilogram body weight per day

EDD Equations

[1] $EDD_{food} = (IR_{food} \times C_{plants}) \times AUF \times BAV$

[2] $EDD_{water} = IR_{water} \times C_{water} \times AUF \times BAV$

[3] $EDD_{sed} = IR_{sed} \times C_{sed} \times AUF \times BAV$

[4] $EDD_{total} = EDD_{food} + EDD_{water} + EDD_{sed}$

Ingestion Rates (IR)

IR_{food}	0.34	kg/kg BW-day
IR_{water}	0.975	L/kg BW-day
IR_{sed}	0.0068	kg/kg BW-day

createdby: MR (8/5/12)
reviewedby: SMT (8/20/12)

Table 5.1
Summary of risk estimation approach by receptor group, exposure unit, and measurement endpoint
Screening-Level Ecological Risk Assessments
Upper Animas Mining District

receptor group	exposure units	measure of effect		risk estimation approach
		exposure	effect	
benthic invertebrate community	Animas River at and below Silverton only	total metals in bulk sediment	sediment screening benchmarks	HQ method
	Mainstem Cement Creek & mainstem Mineral Creek	dissolved metals in surface water	surface water screening benchmarks	HQ method
fish community	Mainstem Cement, mainstem Mineral Creek, Animas River at and below Silverton	dissolved metals in surface water	surface water screening benchmarks	HQ method
insectivorous birds	Animas River at and below Silverton only	exposure modeling to calculate an EDD	bird no-effect TRVs	HQ method
omnivorous birds	Animas River at and below Silverton only	exposure modeling to calculate an EDD	bird no-effect TRVs	HQ method
piscivorous birds	Animas River at and below Silverton only	exposure modeling to calculate an EDD	bird no-effect TRVs	HQ method
herbivorous mammals	Animas River at and below Silverton only	exposure modeling to calculate an EDD	mammal no-effect TRVs	HQ method

EDD = estimated daily dose

HQ = hazard quotient

TRV = toxicity reference value

created by: SJP (8/2/12)

reviewed by: SMT (8/20/12)

Table 5.2
HQs for Non Hardness-Dependent Metals in Surface Water from the Three Waterways
Screening-Level Ecological Risk Assessments
Upper Animas Mining District

Exposure Unit	Hydrologic Period	Sampling Location	pH (unitless)			Aluminum (ug/L)			Beryllium (ug/L)			Iron (ug/L)		
			Min. EPC	Benchmark	Hazard Quotient[a]	Max. EPC	Benchmark	Hazard Quotient	Max. EPC	Benchmark	Hazard Quotient	Max. EPC	Benchmark	Hazard Quotient
Cement Creek	pre-runoff	CC48	3.42	6.00	> **1**	8450	87	**97.1**	1.3	0.66	**2.0**	13300	1000	**13.3**
	runoff	CC21	4.50	6.00	> **1**	1190	87	**13.7**	1.0	0.66	**1.5**	3410	1000	**3.4**
		CC41	4.06	6.00	> **1**	2410	87	**27.7**	1.0	0.66	**1.5**	5880	1000	**5.9**
		CC48	4.29	6.00	> **1**	2890	87	**33.2**	1.0	0.66	**1.5**	5360	1000	**5.4**
	post-runoff	CC48	3.24	6.00	> **1**	7850	87	**90.2**	1.2	0.66	**1.8**	11700	1000	**11.7**
Mineral Creek	pre-runoff	M34	4.97	6.00	> **1**	4700	87	**54.0**	0.5	0.66	0.8	2490	1000	**2.5**
	runoff	M34	6.49	6.00	< **1**	117	87	**1.3**	1.0	0.66	**1.5**	512	1000	0.5
	post-runoff	M34	5.62	6.00	> **1**	656	87	**7.5**	0.5	0.66	0.8	4160	1000	**4.2**
Animas River at & below Silverton	pre-runoff	A72	5.04	6.00	> **1**	3290	87	**37.8**	0.5	0.66	0.8	3250	1000	**3.3**
	runoff	A72	6.51	6.00	< **1**	50	87	0.6	1.0	0.66	**1.5**	746	1000	0.7
	post-runoff	A72	5.93	6.00	> **1**	959	87	**11.0**	0.5	0.66	0.8	3020	1000	**3.0**

HQs > 1.0 are bolded

[a] an HQ cannot be calculated because the pH scale is logarithmic

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 5.3
HQs for Hardness-Dependent Metals in Surface Water from the Three Waterways
Screening-level Ecological Risk Assessments
Upper Animas Mining District

Exposure Unit	Hydrologic Period	Sampling Location	Cadmium (ug/L)			Copper (ug/L)			Lead (ug/L)			Manganese (ug/L)			Silver (ug/L)			Zinc (ug/L)		
			Max. EPC	Hardn. Adj. Benchmark	Hazard Quotient	Max. EPC	Hardn. Adj. Benchmark	Hazard Quotient	Max. EPC	Hardn. Adj. Benchmark	Hazard Quotient	Max. EPC	Hardn. Adj. Benchmark	Hazard Quotient	Max. EPC	Hardn. Adj. Benchmark	Hazard Quotient	Max. EPC	Hardn. Adj. Benchmark	Hazard Quotient
Cement Creek	pre-runoff	CC48	4.9	0.97	**5.1**	110	23.0	**4.8**	14.3	8.2	**1.8**	5290	2947	**1.8**	0.25	0.50	0.5	2600	524	**5.0**
	runoff	CC21	4.8	0.56	**8.6**	92.2	12.0	**7.4**	7.4	3.8	**1.9**	2410	1875	**1.3**	0.25	0.15	**1.7**	1710	173	**9.9**
		CC41	3.4	0.60	**5.7**	77.4	13.0	**5.8**	12.9	4.2	**3.1**	1750	1925	0.9	0.25	0.17	**1.5**	1230	185	**6.7**
		CC48	2.1	0.36	**5.8**	72.0	8.0	**9.0**	9.0	1.9	**4.8**	1770	2039	0.9	0.25	0.05	**5.3**	614	98.0	**6.2**
	post-runoff	CC48	7.0	1.27	**5.5**	221.0	33.0	**6.6**	17.4	9.4	**1.9**	5270	2810	**1.9**	0.25	0.23	**1.1**	2890	504	**5.7**
Mineral Creek	pre-runoff	M34	2.0	0.57	**3.5**	12.3	13.0	**1.0**	4.2	6.6	0.6	634	2399	0.3	0.25	0.15	**1.7**	499	176	**2.8**
	runoff	M34	0.3	0.26	**1.2**	5.0	4.9	**1.0**	0.5	1.1	0.4	160	1327	0.1	0.25	0.02	**11.4**	68.6	68.0	**1.0**
	post-runoff	M34	1.0	0.81	**1.2**	10.0	6.2	**1.6**	0.5	1.6	0.3	592	2202	0.3	0.25	0.04	**7.0**	317	260	**1.2**
Animas River at & below Silverton	pre-runoff	A72	2.9	0.65	**4.5**	35.9	26.0	**1.4**	2.7	9.6	0.3	2920	2472	**1.2**	0.25	0.20	**1.2**	864	202	**4.3**
	runoff	A72	0.8	0.27	**3.0**	5.0	5.3	0.9	0.5	1.0	0.5	504	1575	0.3	0.25	0.02	**13.1**	217	75.0	**2.9**
	post-runoff	A72	2.8	0.95	**2.9**	36.9	23.0	**1.6**	0.5	1.8	0.3	2490	2368	**1.1**	0.25	0.05	**5.5**	1120	314	**3.6**

HQs > 1.0 are bolded

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 5.4
Hazard Quotients for metals in sediment from the Animas River
Screening-level Ecological Risk Assessments
Upper Animas Mining District

Exposure Unit	Hydrologic Period	Arsenic (mg/kg)			Beryllium (mg/kg)			Cadmium (mg/kg)			Copper (mg/kg)			Lead (mg/kg)			Manganese (mg/kg)			Selenium (mg/kg)			Silver (mg/kg)			Zinc (mg/kg)		
		Max. EPC	Benchmark	HQ	Max. EPC	Benchmark	HQ	Max. EPC	Benchmark (mg/kg)	HQ	Max. EPC	Benchmark	HQ	Max. EPC	Benchmark	HQ	Max. EPC	Benchmark	HQ	Max. EPC	Benchmark	HQ	Max. EPC	Benchmark	HQ	Max. EPC	Benchmark	HQ
Animas River at & below Silverton	pre-runoff	no sediment samples collected during the pre-runoff period																										
	runoff	46.2	9.8	**4.7**	2.2	NA	--	8.0	0.99	**8.1**	370	31.6	**11.7**	948	35.8	**26.5**	7070	630	**11.2**	2.3	NA	--	5.0	1.0	**5.0**	2240	121	**18.5**
	post-runoff	no sediment samples collected during the post-runoff period																										

HQs > 1.0 are bolded

created by: SJP (8/2/12)
reviewed by: SMT (8/20/12)

Table 5.5
HQs for the American Dipper Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

COPECs	Pre-Runoff Period			Runoff Period			Post-Runoff Period		
	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ*	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ
Metals, Total									
Aluminum	14371	110	**131**	10200	110	**93.0**	8901	110	**81.1**
Arsenic	0.117	2.2	<1	1.0	2.2	<1	0.117	2.2	<1
Beryllium	0.018	--	--	0.070	--	--	0.018	--	--
Cadmium	8.0	1.5	**5.4**	3.4	1.5	**2.3**	7.4	1.5	**5.1**
Chromium	6.0	2.7	**2.2**	6.1	2.7	**2.3**	6.0	2.7	**2.2**
Copper	124	4.1	**30.7**	113	4.1	**27.8**	138	4.1	**34.1**
Iron	7.3	--	--	1403	--	--	5.2	--	--
Lead	59.2	1.6	**36.3**	417	1.6	**256**	28.2	1.6	**17.3**
Manganese	2.9	179	<1	113	179	<1	2.3	179	<1
Nickel	0.157	6.7	<1	0.233	6.7	<1	0.141	6.7	<1
Selenium	0.502	0.29	**1.7**	1.3	0.29	**4.5**	0.502	0.29	**1.7**
Silver	0.059	2.0	<1	0.376	2.0	<1	0.059	2.0	<1
Zinc	4810	66.1	**72.8**	1151	66.1	**17.4**	4154	66.1	**62.9**

* These HQs include sediment ingestion
mg/kg bw-day - milligrams per kilogram of body weight per day
COPECs - Chemicals of Potential Ecological Concern
EDD - Estimated Daily Dose
NA- Not analyzed
TRV - Toxicity Reference Value
HQ - Hazard Quotient, calculated by dividing the EDD by the TRV
-- - An HQ could not be calculated because no TRV was available or no EDD was calculated

created by: MR (8/5/12)
reviewed by: SMT (8/20/12)

Table 5.6
HQs for the Mallard Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

COPECs	Pre-Runoff Period			Runoff Period			Post-Runoff Period		
	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ*	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ
Metals, Total									
Aluminum	3372	110	**30.7**	3880	110	**35.4**	2088	110	**19.0**
Arsenic	0.114	2.2	<1	0.171	2.2	<1	0.114	2.2	<1
Beryllium	0.014	--	--	0.017	--	--	0.014	--	--
Cadmium	1.9	1.5	**1.3**	1.3	1.5	<1	1.8	1.5	**1.2**
Chromium	2.9	2.7	**1.1**	2.3	2.7	<1	2.9	2.7	**1.1**
Copper	27.7	4.1	**6.8**	42.1	4.1	**10.4**	30.8	4.1	**7.6**
Iron	2.8	--	--	111	--	--	2.0	--	--
Lead	15.4	1.6	**9.5**	158	1.6	**96.7**	7.3	1.6	**4.5**
Manganese	1.1	179	<1	9.0	179	<1	0.904	179	<1
Nickel	0.097	6.7	<1	0.032	6.7	<1	0.087	6.7	<1
Selenium	0.241	0.29	<1	0.492	0.29	**1.7**	0.241	0.29	<1
Silver	0.426	2.0	<1	0.122	2.0	<1	0.426	2.0	<1
Zinc	1382	66.1	**20.9**	437	66.1	**6.6**	1193	66.1	**18.1**

* These HQs include sediment ingestion
mg/kg bw-day - milligrams per kilogram of body weight per day
COPECs - Chemicals of Potential Ecological Concern
EDD - Estimated Daily Dose
NA- Not analyzed
TRV - Toxicity Reference Value
HQ - Hazard Quotient, calculated by dividing the EDD by the TRV
-- - An HQ could not be calculated because no TRV was available or no EDD was calculated

created by: MR (8/5/12)
reviewed by: SMT (8/20/12)

Table 5.7
HQs for the Belted Kingfisher Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

COPECs	Pre-Runoff Period			Runoff Period			Post-Runoff Period		
	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ
Metals, Total									
Aluminum	6.5	110	<1	4.5	110	<1	4.0	110	<1
Arsenic	0.114	2.2	<1	0.286	2.2	<1	0.114	2.2	<1
Beryllium	0.016	--	--	0.031	--	--	0.016	--	--
Cadmium	1.3	1.5	<1	0.544	1.5	<1	1.2	1.5	<1
Chromium	0.024	2.7	<1	0.024	2.7	<1	0.024	2.7	<1
Copper	14.9	4.1	**3.7**	12.8	4.1	**3.2**	16.6	4.1	**4.1**
Iron	4.7	--	--	3.2	--	--	3.4	--	--
Lead	0.002	1.6	<1	0.016	1.6	<1	0.001	1.6	<1
Manganese	1.9	179	<1	0.461	179	<1	1.5	179	<1
Nickel	0.274	6.7	<1	0.078	6.7	<1	0.246	6.7	<1
Selenium	0.032	0.29	<1	0.081	0.29	<1	0.032	0.29	<1
Silver	0.011	2.0	<1	0.055	2.0	<1	0.011	2.0	<1
Zinc	1359	66.1	**20.6**	315	66.1	**4.8**	1174	66.1	**17.8**

HQs > 1.0 are bolded
mg/kg bw-d - milligrams per kilogram of body weight per day
COPECs - Chemicals of Potential Ecological Concern
EDD - Estimated Daily Dose
NA- Not analyzed
TRV - Toxicity Reference Value
HQ - Hazard Quotient, calculated by dividing the EDD by the TRV
-- - An HQ could not be calculated because no TRV was available or no EDD was calculated

created by: MR (8/5/12)
reviewed by: SMT (8/20/12)

Table 5.8
HQs for the Muskrat Feeding in the Animas River at and below Silverton - Maximum EPCs
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

COPECs	Pre-Runoff Period			Runoff Period			Post-Runoff Period		
	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ*	Total EDD (mg/kg bw-d)	No Effect TRV (mg/kg bw-d)	No Effect HQ
Metals, Total									
Aluminum	1262	1.9	**654**	996	1.9	**516**	782	1.9	**405**
Arsenic	0.201	1.0	<1	0.817	1.0	<1	0.201	1.0	<1
Beryllium	0.024	0.532	<1	0.064	0.532	<1	0.024	0.532	<1
Cadmium	0.774	0.77	**1.0**	0.375	0.77	<1	0.721	0.77	<1
Chromium	3.7	2.4	**1.6**	3.8	2.4	**1.6**	3.7	2.4	**1.6**
Copper	7.8	5.6	**1.4**	9.2	5.6	**1.6**	8.6	5.6	**1.5**
Iron	10.1	--	**--**	604	--	**--**	7.2	--	**--**
Lead	8.5	4.7	**1.8**	64.4	4.7	**13.7**	4.1	4.7	<1
Manganese	4.1	51.4	<1	49.1	51.4	<1	3.2	51.4	<1
Nickel	0.152	1.7	<1	0.124	1.7	<1	0.137	1.7	<1
Selenium	0.314	0.143	**2.2**	0.801	0.143	**5.6**	0.314	0.143	**2.2**
Silver	0.909	6.0	<1	4.6	6.0	<1	0.909	6.0	<1
Zinc	977	75.4	**13.0**	242	75.4	**3.2**	844	75.4	**11.2**

* These HQs include sediment ingestion

mg/kg bw-day - milligrams per kilogram of body weight per day

COPECs - Chemicals of Potential Ecological Concern

EDD - Estimated Daily Dose

NA- Not analyzed

TRV - Toxicity Reference Value

HQ - Hazard Quotient, calculated by dividing the EDD by the TRV

-- - An HQ could not be calculated because no TRV was available or no EDD was calculated

created by: MR (8/5/12)

reviewed by: SMT (8/20/12)

Appendix 1

Total and dissolved metals measured in surface water samples from the three waterways

Appendix 1.a: Field pH measurements in surface water samples collected between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Measurement	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**	**pH**
Mineral Creek																				
M34	4.97	5.02	6.22	5.12	6.49	7.30	7.00	7.19	7.07	7.19	6.73	6.70	5.62	6.77	6.73	6.4	7.28	6.82	6.68	5.90
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	4.50	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	4.06	--	--	--	--	--	--	--	--	--	--	--
CC48	3.5	3.42	3.93	3.54	5.40	4.29	5.34	5.24	4.43	3.95	3.51	3.65	3.50	3.57	3.45	3.51	4.54	3.45	3.51	3.24
Animas River																				
A68 (reference)	6.74	6.82	6.85	7.18	7.15	7.51	6.98	7.28	7.37	7.61	7.18	7.21	6.52	6.92	7.52	7.26	7.42	7.2	7.39	6.87
A72	5.07	5.04	6.09	5.3	7.08	7.09	6.51	6.5	6.59	6.88	6.40	6.46	5.93	6.41	6.48	6.25	7.08	6.51	6.38	6.23
Opp sample 1	--	--	--	--	--	--	--	--	6.80	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	6.86	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	6.89	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	6.89	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	6.89	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	6.84	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	6.84	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	6.85	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	6.75	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	6.81	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.b: Hardness measurements in surface water samples collected between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Measurement	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**	**hardness**
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Mineral Creek																				
M34	309	308	150	247	52	72	49	53	77	91	186	156	238	114	199	219	65	144	188	155
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	147	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	159	--	--	--	--	--	--	--	--	--	--	--
CC48	571	541	301	493	81	189	88	76	177	293	467	470	495	345	509	517	191	398	474	435
Animas River																				
A68 (reference)	202	179	148	172	49	65	50	53	71	85	135	141	167	97	144	154	66	111	140	138
A72	352	337	177	273	45	78	54	55	86	109	211	199	296	136	245	232	75	161	210	183
Opp sample 1	--	--	--	--	--	--	--	--	86	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	87	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	88	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	87	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	86	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	85	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	88	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	86	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	86	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	87	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.c: Total and Dissolved Aluminum Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**	**Al-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	5950	5360	2160	4830	1130	773	665	2200	824	933	2630	2480	4590	1200	2960	3080	563	1600	2610	2170
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	2270	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	2710	--	--	--	--	--	--	--	--	--	--	--
CC48	8610	8100	5020	7540	1780	2920	1750	1610	2690	4120	7110	7050	7850	5270	7230	7930	2710	5830	6770	6810
Animas River																				
A68 (reference)	269	177	368	275	1010	165	348	540	154	117	120	134	189	100 U	124	101	217	100 U	100 U	100 U
A72	4440	4090	1980	3310	3060	679	585	1200	713	812	2080	2080	2750	1090	2180	2540	597	1370	2070	1800
Opp sample 1	--	--	--	--	--	--	--	--	687	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	691	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	709	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	687	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	695	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	683	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	705	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	699	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	696	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	666	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**	**Al-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	4410	4700	160	3020	100 U	100 U	117	100 U	45.0 J	100 U	100 U	100 U	656	100 U	25.0 U	25.0 U	100 U	100 U	100 U	100 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	1190	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	2410	--	--	--	--	--	--	--	--	--	--	--
CC48	8450	7820	4840	7660	751	2890	1050	798	2470	4050	7050	6930	7850	5270	7440	7720	2410	6030	7290	6770
Animas River																				
A68 (reference)	141	100 U	100 U	100 U	100 U	100 U	100 U	100 U	57.2	100 U	100 U	100 U	103	100 U	25.0 U	25.0 U	100 U	100 U	100 U	100 U
A72	3290	2740	212	1570	100 U	100 U	100 U	100 U	33.6 J	100 U	131	171	959	100 U	25.0 U	193	100 U	100 U	117	103
Opp sample 1	--	--	--	--	--	--	--	--	32.0 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	32.1 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	33.3 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	30.6 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	33.4 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	31.3 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	31.5 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	30.7 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	29.8 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	30.6 J	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.d: Total and Dissolved Arsenic Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	Feb 2010	March 2010	April 2010	March 2011	May 2009	June 2009	June 2010	June 2011	May 2012	July 2009	Aug 2009	Sept 2009	Nov 2009	July 2010	Sept 2010	Nov 2010	July 2011	Aug 2011	Sept 2011	Oct 2011
Metal-fraction	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total	As-total
Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Mineral Creek																				
M34	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.5	2.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Cement Creek																				
CC21	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
CC41	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
CC48	7.7	6.6	4.0 U	5.0	4.0 U	4.0 U	4.0 U	4.0 U	2.5 U	4.0 U	4.0 U	4.0	5.4	4.0 U	1.0 U	4.3	4.0 U	4.0 U	4.0 U	4.0 U
Animas River																				
A68 (reference)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	2.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
A72	4.0 U	4.0 U	4.0 U	4.0 U	5.0	4.0 U	4.0 U	4.0 U	2.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Opp sample 1	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 2	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 3	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 4	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 5	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 6	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 7	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 8	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 9	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 10	–	–	–	–	--	–	–	–	2.5 U	–	--	--	–	–	--	–	–	–	--	–

Sampling Date	Feb 2010	March 2010	April 2010	March 2011	May 2009	June 2009	June 2010	June 2011	May 2012	July 2009	Aug 2009	Sept 2009	Nov 2009	July 2010	Sept 2010	Nov 2010	July 2011	Aug 2011	Sept 2011	Oct 2011
Metal-fraction	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss	As-diss
Units	ug/L	µg/L	µg/L	µg/L	ug/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Mineral Creek																				
M34	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	0.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Cement Creek																				
CC21	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
CC41	–	–	–	–	--	–	–	–	0.5 J	–	--	--	–	–	--	–	–	–	--	–
CC48	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	0.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Animas River																				
A68 (reference)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	0.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
A72	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	0.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.0 U	1.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Opp sample 1	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 2	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 3	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 4	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 5	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 6	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 7	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 8	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 9	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–
Opp sample 10	–	–	–	–	--	–	–	–	0.5 U	–	--	--	–	–	--	–	–	–	--	–

Appendix 1.e: Total and Dissolved Beryllium Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**	**Be-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Cement Creek																				
CC21	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
CC41	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
CC48	1.3	1.3	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.2	1.2	1.2	1.0 U	1.3	1.4	1.0 U	1.0 U	1.0	1.0
Animas River																				
A68 (reference)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
A72	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Opp sample 1	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 2	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 3	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 4	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 5	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 6	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 7	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 8	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 9	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 10	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**	**Be-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Cement Creek																				
CC21	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
CC41	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
CC48	1.2	1.1	1.0 U	1.3	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.1	1.2	1.2	1.0 U	0.2 U	1.1	1.0 U	1.1	1.1	1.0
Animas River																				
A68 (reference)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
A72	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Opp sample 1	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 2	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 3	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 4	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 5	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 6	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 7	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 8	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 9	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–
Opp sample 10	–	–	--	–	–	–	--	–	2.0 U	–	--	–	--	--	--	--	–	–	--	–

Appendix 1.f: Total and Dissolved Cadmium Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**	**Cd-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.1	1.1	1.8	1.2	0.3	0.2	0.3	0.4	0.5 U	0.4	0.7	0.7	0.9	0.4	0.7	0.7	0.3	0.5	0.7	0.6
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	5.0 D	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	3.3 D	--	--	--	--	--	--	--	--	--	--	--
CC48	5.5	5.6	4.8	5.0	2.1	3.3	2.3	2.0	2.8 D	4.4	6.4	6.7	6.3	4.8	5.8	6.8	3.1	5.3	5.7	7.1
Animas River																				
A68 (reference)	2.0	1.7	4.0	2.6	1.5	0.9	1.1	1.1	0.9 JD	0.8	1.0	1.3	1.6	0.8	1.3	1.3	0.8	1.0	1.1	1.2
A72	2.5	2.8	2.9	2.7	1.2	0.8	0.9	0.9	0.9 JD	0.9	1.7	1.9	2.7	1.2	1.7	2.0	0.8	1.4	1.7	1.7
Opp sample 1	--	--	--	--	--	--	--	--	1.0 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	0.8 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	1.1 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	0.8 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	0.9 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	1.0 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	0.8 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	0.9 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	0.8 JD	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	1.1 D	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**	**Cd-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.1	1.0	2.0	1.1	0.3	0.2	0.2 U	0.2	0.3	0.3	0.7	0.7	1.0	0.4	0.7	0.8	0.2	0.5	0.7	0.6
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	4.8	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	3.4	--	--	--	--	--	--	--	--	--	--	--
CC48	5.5	5.3	4.9	5.3	2.1	3.4	2.2	2.0	2.9	4.6	6.6	6.6	6.4	4.4	5.7	6.7	3.1	5.6	5.9	7.0
Animas River																				
A68 (reference)	1.8	1.6	4.1	2.7	0.9	0.8	0.9	0.9	0.9	0.8	1.0	1.2	1.7	0.8	1.3	1.4	0.8	0.9	1.1	1.1
A72	2.6	2.7	2.9	2.6	0.6	0.8	0.7	0.8	0.9	0.9	1.8	1.8	2.8	1.1	1.8	2.1	0.7	1.3	1.7	1.6
Opp sample 1	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	0.9	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	0.9	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	0.9	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.g: Total and Dissolved Chromium Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**	**Cr-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	5.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
CC48	2.0 U	4.3	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	5.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
Animas River																				
A68 (reference)	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	5.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
A72	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	5.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
Opp sample 1	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	5.0 U	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**	**Cr-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	1.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
CC48	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	1.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
Animas River																				
A68 (reference)	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	1.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
A72	2.0 U	2.0 U	2.0 U	5.0 U	2.0 U	2.0 U	5.0 U	5.0 U	1.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5.0 U	0.5 U	0.5 U	5.0 U	5.0 U	5.0 U	5.0 U
Opp sample 1	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	1.0 U	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.h: Total and Dissolved Copper Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**	**Cu-total**
Units	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**
Mineral Creek																				
M34	13.1	13.8	21.6	19.4	14.5	8.5	10.0 U	12.8	5.7 D	6.6	12.0	12.8	18.1	10.0 U	11.7	12.3	20.0 U	20.0 U	20.0 U	20.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	105 D	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	78.3 D	--	--	--	--	--	--	--	--	--	--	--
CC48	122	116	110	90.9	64.3	94.6	78.0	61.3	61.5 D	115	224	192	159	126	174	141	82.8	147	156	136
Animas River																				
A68 (reference)	6.2	7.7	22.3	14.7	21.2	5.8	10.0 U	10.9	5.9 D	4.0	3.9	4.0	5.1	10.0 U	4.0 U	4.0 U	20.0 U	20.0 U	20.0 U	20.0 U
A72	42.0	40.5	34.9	33.5	36.1	14.8	13.4	16.5	12.0 D	15.7	40.7	34.1	46.7	19.8	33.6	31.4	20.0 U	22.2	28.8	24.2
Opp sample 1	--	--	--	--	--	--	--	--	11.3 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	11.8 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	11.8 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	12.3 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	10.8 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	12.2 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	11.6 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	11.9 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	11.2 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	12.4 D	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**	**Cu-diss**
Units	**ug/L**	**μg/L**	**μg/L**	**μg/L**	**ug/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**	**μg/L**
Mineral Creek																				
M34	10.3	11.2	12.3	16.2	3.9	3.0 U	10.0 U	10.0 U	1.7	3.0 U	3.4	3.7	9.5	10.0 U	4.0 U	4.0 U	20.0 U	20.0 U	20.0 U	20.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	92.2	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	77.4	--	--	--	--	--	--	--	--	--	--	--
CC48	119	109	110	89.1	56.3	90.6	72.0	55.6	61.2	110	221	189	152	118	166	140	76.6	145	148	139
Animas River																				
A68 (reference)	3.0 U	3.0 U	8.3	10.0 U	4.5	3.7	10.0 U	10.0 U	4.3	3.0 U	3.0 U	3.0 U	3.0 U	10.0 U	4.0 U	4.0 U	20.0 U	20.0 U	20.0 U	20.0 U
A72	35.9	35.2	19.2	25.2	3.6	4.5	10.0 U	10.0 U	4.1	4.8	17.4	14.7	36.9	10.0 U	13.0	14.5	20.0 U	20.0 U	20.0 U	20.0 U
Opp sample 1	--	--	--	--	--	--	--	--	3.6	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	3.6	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	3.5	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	3.5	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	3.5	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	3.5	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	3.7	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	3.6	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	3.9	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	3.9	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.i: Total and Dissolved Iron Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**	**Fe-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	6830	6380	4180	6080	2130	1060	1040	4200	1170	1340	3560	3500	8290	1780	4300	4870	754	2430	3340	3100
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	7240	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	7130	--	--	--	--	--	--	--	--	--	--	--
CC48	21700	19400	12700	14800	3950	4440	4160	3610	6510	6030	10800	13400	18600	5460	11500	14200	5230	7290	8630	11700
Animas River																				
A68 (reference)	293	235	225	208	1100	100 U	376	544	111 J	100 U	115	151	234	100 U	129	169	189	116	158	169
A72	7710	7090	4190	5080	5300	948	986	1950	1270	1060	2990	3330	5490	1320	3230	4330	787	1750	2500	2740
Opp sample 1	--	--	--	--	--	--	--	--	1270	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	1270	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	1330	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	1270	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	1340	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	1260	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	1290	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	1270	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	1270	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	1220	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**	**Fe-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	2490	2470	1700	2390	139	374	173	100 U	512	764	2440	2050	4160	1190	3170	3900	337	1740	2400	2400
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	3410	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	5880	--	--	--	--	--	--	--	--	--	--	--
CC48	13300	9640	8610	10000	2000	3090	2300	2320	5360	3670	7750	9530	11600	4300	9010	11700	3600	5520	7110	8730
Animas River																				
A68 (reference)	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	10.0 U	10.0 U	100 U	100 U	100 U	100 U
A72	3250	2500	1940	1800	100 U	343	224	199	746	463	1340	1500	3020	556	1610	2160	280	703	1050	1300
Opp sample 1	--	--	--	--	--	--	--	--	665	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	646	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	659	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	662	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	667	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	730	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	712	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	693	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	692	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	673	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.j: Total and Dissolved Lead Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**	**Pb-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	5.9	6.3	24.8	11.5	15.6	3.1	7.9	45.7	3.2 D	2.9	3.2	5.2	10.5	4.1	4.1	7.0	3.5	3.9	4.1	4.7
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	32.3 D	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	19.4 D	--	--	--	--	--	--	--	--	--	--	--
CC48	19.0	17.0	19.7	17.8	18.0	11.1	24.1	22.1	11.9 D	14.0	15.4	17.3	18.6	19.6	18.2	17.4	14.8	20.0	21.0	20.5
Animas River																				
A68 (reference)	2.7	2.4	4.4	5.4	52.3	2.5	15.3	19.6	2.8 D	2.1	1.4	2.0	1.9	1.5	2.2	1.7	4.9	1.7	1.7	1.7
A72	8.9	6.6	14.7	9.2	99.8	3.3	12.3	24.8	4.3 D	4.0	4.5	5.8	6.2	5.8	5.6	7.0	6.0	4.8	5.6	5.6
Opp sample 1	--	--	--	--	--	--	--	--	3.7 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	4.0 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	4.4 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	4.2 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	3.8 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	6.4 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	4.3 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	5.9 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	4.9 D	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	4.3 D	--	--	--	--	--	--	--	--	--	--	--

Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**	**Pb-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.5	2.0	1.7	4.2	1.0 U	1.0 U	1.0 U	1.0 U	0.1 J	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	7.4	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	12.9	--	--	--	--	--	--	--	--	--	--	--
CC48	13.2	14.2	14.3	15.1	4.2	9.6	8.0	9.0	8.0	13.0	16.8	14.5	16.2	17.4	16.8	17.1	8.5	19.2	21.4	18.7
Animas River																				
A68 (reference)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.6	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
A72	2.7	1.3	1.0 U	1.5	1.0 U	1.0 U	1.0 U	1.0 U	0.1 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Opp sample 1	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	0.1 U	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.k: Total and Dissolved Manganese Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**	**Mn-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	615	559	328	567	219	130	112	313	123	174	401	374	596	209	440	429	115	275	394	302
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	2600	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	1790	--	--	--	--	--	--	--	--	--	--	--
CC48	5120	5490	3190	4950	809	1810	865	739	1660	2850	4900	5100	5530	3190	4780	5140	1790	3780	4490	4700
Animas River																				
A68 (reference)	3550	2830	3980	3200	697	697	435	550	715	676	1290	1580	2320	668	1280	1770	571	868	1120	1300
A72	2710	3110	1850	2440	755	492	311	397	488	596	1380	1430	2470	734	1450	1690	439	923	1290	1220
Opp sample 1	--	--	--	--	--	--	--	--	490	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	491	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	504	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	491	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	503	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	481	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	493	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	491	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	493	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	499	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**	**Mn-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	630	634	324	530	160	120	84.9	150	115	169	410	336	592	212	435	456	104	293	406	303
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	2410	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	1750	--	--	--	--	--	--	--	--	--	--	--
CC48	5290	5200	3040	4940	766	1770	811	731	1620	2830	4810	4920	5270	3280	5030	5220	1740	3890	4900	4620
Animas River																				
A68 (reference)	3560	2710	3730	3160	340	636	335	415	699	668	1320	1540	2380	649	1310	1790	537	821	1140	1310
A72	2710	2920	1770	2340	219	450	241	305	471	603	1420	1370	2490	736	1590	1690	405	923	1290	1180
Opp sample 1	--	--	--	--	--	--	--	--	483	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	487	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	486	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	504	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	488	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	480	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	483	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	477	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	477	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	495	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.I: Total and Dissolved Nickel Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**	**Ni-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	4.0	3.2	2.0 U	4.0 U	2.0 U	2.0 U	4.0 U	4.0 U	2.5 U	2.0 U	2.3	2.0 U	3.7	4.0 U	0.7 U	0.7 U	4.0 U	4.0 U	4.0 U	4.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	4.2 JD	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	4.9 JD	--	--	--	--	--	--	--	--	--	--	--
CC48	17.8	17.9	9.7	14.8	2.0	6.6	4.3	4.0 U	4.8 JD	10	16.3	15.7	17.3	10	15.1	17.1	6.4	12.3	14	13.4
Animas River																				
A68 (reference)	2.0 U	2.0 U	2.0 U	4.0 U	2.0 U	2.0 U	4.0 U	4.0 U	2.5 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	0.7 U	0.7 U	4.0 U	4.0 U	4.0 U	4.0 U
A72	7.0	7.0	2.0 U	5.2	2.0 U	2.0 U	4.0 U	4.0 U	2.5 U	2.0	3.9	3.3	6.3	4.0 U	0.7 U	5.4	4.0 U	4.0 U	4.0 U	4.0 U
Opp sample 1	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**	**Ni-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	5.3	3.3	2.0 U	4.0	2.0 U	2.0 U	4.0 U	4.0 U	0.6 J	2.0 U	2.1	2.3	4.1	4.0 U	0.7 U	0.7 U	4.0 U	4.0 U	4.0 U	4.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	4.3	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	5.3	--	--	--	--	--	--	--	--	--	--	--
CC48	19.4	16.3	10.3	16.4	2.2	5.3	4.0 U	4.0 U	4.9	9.1	15.0	15.7	17.4	8.6	16.5	16.2	6.0	13.0	14.5	13.7
Animas River																				
A68 (reference)	2.0 U	2.0 U	2.0 U	4.0 U	2.0 U	2.0 U	4.0 U	4.0 U	0.5 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	0.7 U	0.7 U	4.0 U	4.0 U	4.0 U	4.0 U
A72	8.2	6.4	3.4	5.8	2.0 U	2.0 U	4.0 U	4.0 U	0.9 J	2.0 U	3.0	3.7	6.4	4.0 U	0.7 U	4.2	4.0 U	4.0 U	4.0 U	4.0 U
Opp sample 1	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	0.8 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	0.6 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	0.8 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	0.6 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.m: Total and Dissolved Selenium Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**	**Se-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.0 U	1.0	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
CC48	1.0 U	1.3	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Animas River																				
A68 (reference)	1.0 U	1.6	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
A72	1.0 U	1.0	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Opp sample 1	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**	**Se-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
CC48	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Animas River																				
A68 (reference)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
A72	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.5 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.2 U	0.2 U	1.0 U	1.0 U	1.0 U	1.0 U
Opp sample 1	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.n: Total and Dissolved Silver Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**	**Ag-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
CC48	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
Animas River																				
A68 (reference)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5	0.5 U	0.5 U
A72	0.5 U	0.5 U	0.5 U	0.5 U	0.5	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
Opp sample 1	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	2.5 U	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**	**Ag-dissol**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	0.6	0.5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
CC48	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
Animas River																				
A68 (reference)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
A72	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U
Opp sample 1	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	0.5 U	--	--	--	--	--	--	--	--	--	--	--

Appendix 1.o: Total and Dissolved Zinc Concentrations in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

	PRE-RUNOFF PERIOD				RUNOFF PERIOD					POST-RUNOFF PERIOD										
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**	**Zn-total**
Units	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	285	251	573	357	90	94.7	56.8	77.7	80.2	92	194	189	280	114	196	236	62.8	132	169	157
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	1750	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	1210	--	--	--	--	--	--	--	--	--	--	--
CC48	2570	2730	1840	2430	641	1130	655	551	1070	1600	2580	2690	2890	1720	2710	2620	1100	1970	2160	2510
Animas River																				
A68 (reference)	663	597	1180	874	405	324	318	307	289	270	333	413	581	273	380	441	252	290	317	399
A72	1060	1320	966	1080	306	303	221	237	293	310	659	650	1140	393	717	786	251	469	573	600
Opp sample 1	--	--	--	--	--	--	--	--	288	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	288	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	293	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	283	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	291	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	290	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	293	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	290	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	293	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	298	--	--	--	--	--	--	--	--	--	--	--
Sampling Date	**Feb 2010**	**March 2010**	**April 2010**	**March 2011**	**May 2009**	**June 2009**	**June 2010**	**June 2011**	**May 2012**	**July 2009**	**Aug 2009**	**Sept 2009**	**Nov 2009**	**July 2010**	**Sept 2010**	**Nov 2010**	**July 2011**	**Aug 2011**	**Sept 2011**	**Oct 2011**
Metal-fraction	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**	**Zn-diss**
Units	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**ug/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Mineral Creek																				
M34	328	292	499	312	48.1	72.5	68.6	50.0 U	68.2	88.7	180	175	317	106	196	242	54.4	131	170	142
Cement Creek																				
CC21	--	--	--	--	--	--	--	--	1710	--	--	--	--	--	--	--	--	--	--	--
CC41	--	--	--	--	--	--	--	--	1230	--	--	--	--	--	--	--	--	--	--	--
CC48	2670	2600	1600	2340	611	1080	660	614	1070	1620	2650	2570	2650	1800	2730	2890	1090	2140	2430	2400
Animas River																				
A68 (reference)	702	610	985	874	295	270	286	274	281	268	332	407	567	261	410	436	237	282	311	393
A72	1110	1230	864	972	133	249	206	217	284	313	636	617	1120	392	762	754	228	467	590	549
Opp sample 1	--	--	--	--	--	--	--	--	278	--	--	--	--	--	--	--	--	--	--	--
Opp sample 2	--	--	--	--	--	--	--	--	285	--	--	--	--	--	--	--	--	--	--	--
Opp sample 3	--	--	--	--	--	--	--	--	282	--	--	--	--	--	--	--	--	--	--	--
Opp sample 4	--	--	--	--	--	--	--	--	290	--	--	--	--	--	--	--	--	--	--	--
Opp sample 5	--	--	--	--	--	--	--	--	284	--	--	--	--	--	--	--	--	--	--	--
Opp sample 6	--	--	--	--	--	--	--	--	290	--	--	--	--	--	--	--	--	--	--	--
Opp sample 7	--	--	--	--	--	--	--	--	287	--	--	--	--	--	--	--	--	--	--	--
Opp sample 8	--	--	--	--	--	--	--	--	282	--	--	--	--	--	--	--	--	--	--	--
Opp sample 9	--	--	--	--	--	--	--	--	287	--	--	--	--	--	--	--	--	--	--	--
Opp sample 10	--	--	--	--	--	--	--	--	302	--	--	--	--	--	--	--	--	--	--	--

Appendix 2

Total metals measured in bulk sediment samples collected from the Animas River in May 2012

Appendix 2: Total metals measured in bulk sediment samples collected from the Animas River in May 2012

Upper Animas Mining District

Sampling date	May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012		May 2012	
Metal	**Aluminum**		**Arsenic**		**Beryllium**		**Cadmium**		**Chromium**		**Copper**		**Iron**		**Lead**		**Manganese**		**Nickel**		**Selenium**		**Silver**		**Zinc**	
Units	**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**		**mg/kg dw**	
Animas River																										
A68 (reference)	9050	D	25.9	D	2.01	U	13.4	D	5.0	D	374	D	29100	D	1890	D	12200	D	9	D	1.3	D	7.1	D	3030	D
A72	12400	D	37.9	D	1.99	U	2.8	D	6.0	D	153	D	58400	D	582	D	2810	D	6.4	D	1.9	D	1.9	D	753	D
Opp sample 1	13800	D	40.1	D	1.99	U	6.7	D	5.3	D	276	D	74300	D	948	D	6130	D	11.8	D	1.9	D	5.0	D	1670	D
Opp sample 6	18600	D	46.2	D	2.16	JD	8.0	D	5.2	D	370	D	87800	D	935	D	7070	D	8.6	D	2.3	D	4.5	D	2240	D

Opp sample = "opportunity" sample

Appendix 3

Calculating hardness-specific benchmarks and HQs

Appendix 3.a: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Cadmium Concentrations Measured in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.	HQ	3/10	hardness	benchm.	HQ	4/10	hardness	benchm.	HQ	3/11	hardness	benchm.	HQ
Metal-fraction	Cd-diss				Cd-diss				Cd-diss				Cd-diss			
Units	ug/L				µg/L				µg/L				µg/L			
M34	1.1	309	0.99	1.1	1.0	308	0.98	1.0	2.0	150	0.57	3.5	1.1	247	0.83	1.3
CC48	5.5	571	1.56	3.5	5.3	541	1.50	3.5	4.9	301	0.97	5.1	5.3	493	1.40	3.8
A68 (reference)	1.8	202	0.72	2.5	1.6	179	0.65	2.4	4.1	148	0.57	7.2	2.7	172	0.64	4.3
A72	2.6	352	1.09	2.4	2.7	337	1.05	2.6	2.9	177	0.65	4.5	2.6	273	0.90	2.9

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.	HQ	6/09	hardness	benchm.	HQ	6/10	hardness	benchm.	HQ	6/11	hardness	benchm.	HQ	5/12	hardness	benchm.	HQ
Metal-fraction	Cd-diss				Cd-diss				Cd-diss				Cd-diss				Cd-diss			
Units	ug/L				µg/L				µg/L				µg/L				µg/L			
M34	0.3	52	0.26	1.2	0.2	72	0.33	0.6	0.1	49	0.25	0.4	0.2	53	0.26	0.8	0.3	77	0.35	0.8
CC21	--				--				–				--				4.8	147	0.56	8.6
CC41	--				--				–				--				3.4	159	0.60	5.7
CC48	2.1	81	0.36	5.8	3.4	189	0.68	5.0	2.2	88	0.38	5.7	2.0	76	0.34	5.8	2.9	177	0.65	4.5
A68 (reference)	0.9	49	0.25	3.6	0.8	65	0.31	2.6	0.9	50	0.25	3.6	0.9	53	0.26	3.4	0.9	71	0.33	2.7
A72	0.6	45	0.23	2.6	0.8	78	0.35	2.3	0.7	54	0.27	2.6	0.8	55	0.27	3.0	0.9	86	0.38	2.4
Opp sample 1	--				--				–				--				0.8	86	0.38	2.0
Opp sample 2	--				--				–				--				0.8	87	0.38	2.1
Opp sample 3	--				--				–				--				0.9	88	0.38	2.3
Opp sample 4	--				--				–				--				0.9	87	0.38	2.3
Opp sample 5	--				--				–				--				0.9	86	0.38	2.3
Opp sample 6	--				--				–				--				0.8	85	0.37	2.2
Opp sample 7	--				--				–				--				0.8	88	0.38	2.1
Opp sample 8	--				--				–				--				0.8	86	0.38	2.2
Opp sample 9	--				--				–				--				0.8	86	0.38	2.2
Opp sample 10	--				--				–				--				0.8	87	0.38	2.1

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.	HQ	8/09	hardness	benchm.	HQ	9/09	hardness	benchm.	HQ	11/09	hardness	benchm.	HQ	7/10	hardness	benchm.	HQ
Metal-fraction	Cd-diss				Cd-diss				Cd-diss				Cd-diss				Cd-diss			
Units	µg/L				µg/L				µg/L				µg/L				µg/L			
M34	0.3	91	0.39	0.8	0.7	186	0.67	1.0	0.7	156	0.59	1.2	1.0	238	0.81	1.2	0.4	114	0.47	0.9
CC48	4.6	293	0.95	4.9	6.6	467	1.34	4.9	6.6	470	1.35	4.9	6.4	495	1.40	4.6	4.4	345	1.07	4.1
A68 (reference)	0.8	85	0.37	2.1	1.0	135	0.53	1.9	1.2	141	0.55	2.2	1.7	167	0.62	2.7	0.8	97	0.41	1.9
A72	0.9	109	0.45	2.0	1.8	211	0.74	2.4	1.8	199	0.71	2.5	2.8	296	0.95	2.9	1.1	136	0.53	2.1

Sampling Date	9/10	hardness	benchm.	HQ	11/10	hardness	benchm.	HQ	7/11	hardness	benchm.	HQ	8/11	hardness	benchm.	HQ	9/11	hardness	benchm.	HQ	10/11	hardness	benchm.	HQ
Metal-fraction	Cd-diss				Cd-diss				Cd-diss				Cd-diss				Cd-diss				Cd-diss			
Units	µg/L				µg/L				µg/L				µg/L				µg/L				µg/L			
M34	0.7	199	0.71	1.0	0.8	219	0.76	1.1	0.2	65	0.31	0.7	0.5	144	0.56	0.9	0.7	188	0.68	1.0	0.6	155	0.59	1.0
CC48	5.7	509	1.43	4.0	6.7	517	1.45	4.6	3.1	191	0.69	4.5	5.6	398	1.19	4.7	5.9	474	1.36	4.3	7.0	435	1.27	5.5
A68 (reference)	1.3	144	0.56	2.3	1.4	154	0.58	2.4	0.8	66	0.31	2.6	0.9	111	0.46	2.0	1.1	140	0.54	2.0	1.1	138	0.54	2.0
A72	1.8	245	0.83	2.2	2.1	232	0.80	2.6	0.7	75	0.34	2.1	1.3	161	0.60	2.2	1.7	210	0.74	2.3	1.6	183	0.67	2.4

shadingshows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for cadmium was calculated using the following equation: $(1.101672-[\ln(hardness) * (0.041838)] * e^{0.7998[\ln(hardness)]-4.4451}$

Appendix 3.b: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Chromium Concentrations Measured in Surface Water Samples Collected Between 2009 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.		3/10	hardness	benchm.		4/10	hardness	benchm.		3/11	hardness	benchm.	
Metal-fraction	Cr-diss				Cr-diss				Cr-diss				Cr-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	1.0	309	187	0.01	1.0	308	186	0.01	1.0	150	103	0.01	2.5	247	155	0.02
CC48	1.0	571	309	0.00	1.0	541	295	0.00	1.0	301	183	0.01	2.5	493	274	0.01
A68 (reference)	1.0	202	132	0.01	1.0	179	119	0.01	1.0	148	102	0.01	2.5	172	116	0.02
A72	1.0	352	208	0.00	1.0	337	200	0.00	1.0	177	118	0.01	2.5	273	169	0.01

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.		6/09	hardness	benchm.		6/10	hardness	benchm.		6/11	hardness	benchm.		5/12	hardness	benchm.	
Metal-fraction	Cr-diss				Cr-diss				Cr-diss				Cr-diss				Cr-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	1.0	52	43	0.02	1.0	72	57	0.02	2.5	49	41	0.06	2.5	53	44	0.06	0.5	77	60	0.01
CC21	--				--				--				--				0.5	147	102	0.00
CC41	--				--				--				--				0.5	159	108	0.00
CC48	1.0	81	62	0.02	1.0	189	125	0.01	2.5	88	67	0.04	2.5	76	59	0.04	0.5	177	118	0.00
A68 (reference)	1.0	49	41	0.02	1.0	65	52	0.02	2.5	50	42	0.06	2.5	53	44	0.06	0.5	71	56	0.01
A72	1.0	45	39	0.03	1.0	78	60	0.02	2.5	54	45	0.06	2.5	55	45	0.06	0.5	86	66	0.01
Opp sample 1	--				--				--				--				0.5	86	66	0.01
Opp sample 2	--				--				--				--				0.5	87	66	0.01
Opp sample 3	--				--				--				--				0.5	88	67	0.01
Opp sample 4	--				--				--				--				0.5	87	66	0.01
Opp sample 5	--				--				--				--				0.5	86	66	0.01
Opp sample 6	--				--				--				--				0.5	85	65	0.01
Opp sample 7	--				--				--				--				0.5	88	67	0.01
Opp sample 8	--				--				--				--				0.5	86	66	0.01
Opp sample 9	--				--				--				--				0.5	86	66	0.01
Opp sample 10	--				--				--				--				0.5	87	66	0.01

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.		8/09	hardness	benchm.		9/09	hardness	benchm.		11/09	hardness	benchm.		7/10	hardness	benchm.	
Metal-fraction	Cr-diss				Cr-diss				Cr-diss				Cr-diss				Cr-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	1.0	91	69	0.01	1.0	186	123	0.01	1.0	156	107	0.01	1.0	238	151	0.01	2.5	114	83	0.03
CC48	1.0	293	179	0.01	1.0	467	262	0.00	1.0	470	263	0.00	1.0	495	275	0.00	2.5	345	204	0.01
A68 (reference)	1.0	85	65	0.02	1.0	135	95	0.01	1.0	141	98	0.01	1.0	167	113	0.01	2.5	97	72	0.03
A72	1.0	109	80	0.01	1.0	211	137	0.01	1.0	199	130	0.01	1.0	296	180	0.01	2.5	136	95	0.03

Sampling Date	9/10	hardness	benchm.		11/10	hardness	benchm.		7/11	hardness	benchm.		8/11	hardness	benchm.		9/11	hardness	benchm.		10/11	hardness	benchm.	
Metal-fraction	Cr-diss				Cr-diss				Cr-diss				Cr-diss				Cr-diss				Cr-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.3	199	130	0.00	0.3	219	141	0.00	2.5	65	52	0.05	2.5	144	100	0.03	2.5	188	124	0.02	2.5	155	106	0.02
CC48	0.3	509	281	0.00	0.3	517	285	0.00	2.5	191	126	0.02	2.5	398	230	0.01	2.5	474	265	0.01	2.5	435	247	0.01
A68 (reference)	0.3	144	100	0.00	0.3	154	106	0.00	2.5	66	53	0.05	2.5	111	81	0.03	2.5	140	98	0.03	2.5	138	96	0.03
A72	0.3	245	154	0.00	0.3	232	148	0.00	2.5	75	59	0.04	2.5	161	109	0.02	2.5	210	136	0.02	2.5	183	122	0.02

shading shows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for chromium was calculated using the following equation: $e^{(0.819[\ln(hardness)]+0.534)}$

Appendix 3.c: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Copper Concentrations Measured in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.		3/10	hardness	benchm.		4/10	hardness	benchm.		3/11	hardness	benchm.	
Metal-fraction	Cu-diss				Cu-diss				Cu-diss				Cu-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	10.3	309	23	0.4	11.2	308	23	0.5	12.3	150	13	1.0	16.2	247	19	0.8
CC48	119	571	40	3.0	109	541	38	2.9	110	301	23	4.8	89.1	493	35	2.5
A68 (reference)	1.5	202	16	0.1	1.5	179	15	0.1	8.3	148	13	0.7	5.0	172	14	0.4
A72	35.9	352	26	1.4	35.2	337	25	1.4	19.2	177	15	1.3	25.2	273	21	1.2

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.		6/09	hardness	benchm.		6/10	hardness	benchm.		6/11	hardness	benchm.		5/12	hardness	benchm.	
Metal-fraction	Cu-diss				Cu-diss				Cu-diss				Cu-diss				Cu-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	3.9	52	5.1	0.8	1.5	72	6.8	0.2	5.0	49	4.9	1.0	5.0	53	5.2	1.0	1.7	77	7.2	0.2
CC21	--				--				--				--				92.2	147	12	7.4
CC41	--				--				--				--				77.4	159	13	5.8
CC48	56.3	81	7.5	7.5	90.6	189	15.4	5.9	72.0	88	8.0	9.0	55.6	76	7.1	7.8	61.2	177	15	4.2
A68 (reference)	4.5	49	4.9	0.9	3.7	65	6.2	0.6	5.0	50	5.0	1.0	5.0	53	5.2	1.0	4.3	71	6.7	0.6
A72	3.6	45	4.5	0.8	4.5	78	7.2	0.6	5.0	54	5.3	0.9	5.0	55	5.4	0.9	4.1	86	7.9	0.5
Opp sample 1	--				--				--				--				3.6	86	7.9	0.5
Opp sample 2	--				--				--				--				3.6	87	8.0	0.4
Opp sample 3	--				--				--				--				3.5	88	8.0	0.4
Opp sample 4	--				--				--				--				3.5	87	8.0	0.4
Opp sample 5	--				--				--				--				3.5	86	7.9	0.4
Opp sample 6	--				--				--				--				3.5	85	7.8	0.4
Opp sample 7	--				--				--				--				3.7	88	8.0	0.5
Opp sample 8	--				--				--				--				3.6	86	7.9	0.5
Opp sample 9	--				--				--				--				3.9	86	7.9	0.5
Opp sample 10	--				--				--				--				3.9	87	8.0	0.5

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.		8/09	hardness	benchm.		9/09	hardness	benchm.		11/09	hardness	benchm.		7/10	hardness	benchm.	
Metal-fraction	Cu-diss				Cu-diss				Cu-diss				Cu-diss				Cu-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	1.5	91	8.3	0.2	3.4	186	15	0.2	3.7	156	13	0.3	9.5	238	19	0.5	5.0	114	10	0.5
CC48	110	293	22	4.9	221	467	33	6.6	189	470	34	5.6	152	495	35	4.3	118	345	26	4.6
A68 (reference)	1.5	85	7.8	0.2	1.5	135	12	0.1	1.5	141	12	0.1	1.5	167	14	0.1	5.0	97	8.7	0.6
A72	4.8	109	9.6	0.5	17.4	211	17	1.0	14.7	199	16	0.9	36.9	296	23	1.6	5.0	136	12	0.4

Sampling Date	9/10	hardness	benchm.		11/10	hardness	benchm.		7/11	hardness	benchm.		8/11	hardness	benchm.		9/11	hardness	benchm.		10/11	hardness	benchm.	
Metal-fraction	Cu-diss				Cu-diss				Cu-diss				Cu-diss				Cu-diss				Cu-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	2.0	199	16	0.1	2.0	219	17	0.1	10.0	65.0	6.2	1.6	10.0	144	12	0.8	10.0	188	15	0.7	10.0	155	13	0.8
CC48	166	509	36	4.6	140	517	36	3.8	76.6	191	16	4.9	145	398	29	5.0	148	474	34	4.4	139	435	31	4.4
A68 (reference)	2.0	144	12	0.2	2.0	154	13	0.2	10.0	66.0	6.3	1.6	10.0	111	9.8	1.0	10.0	140	12	0.8	10.0	138	12	0.8
A72	13.0	245	19	0.7	14.5	232	18	0.8	10.0	75.0	7.0	1.4	10.0	161	13	0.7	10.0	210	17	0.6	10.0	183	15	0.7

shading shows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for copper was calculated using the following equation: $e^{(0.8545[\ln(\text{hardness})]-1.7428)}$

Appendix 3.d: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Lead Concentrations Measured in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.		3/10	hardness	benchm.		4/10	hardness	benchm.		3/11	hardness	benchm.	
Metal-fraction	Pb-diss				Pb-diss				Pb-diss				Pb-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	1.5	309	8.4	0.2	2.0	308	8.4	0.2	1.7	150	3.9	0.4	4.2	247	6.6	0.6
CC48	13.2	571	15.7	0.8	14.2	541	14.9	1.0	14.3	301	8.2	1.8	15.1	493	13.5	1.1
A68 (reference)	0.5	202	5.4	0.1	0.5	179	4.7	0.1	0.5	148	3.8	0.1	0.5	172	4.5	0.1
A72	2.7	352	9.6	0.3	1.3	337	9.2	0.1	0.5	177	4.7	0.1	1.5	273	7.4	0.2

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.		6/09	hardness	benchm.		6/10	hardness	benchm.		6/11	hardness	benchm.		5/12	hardness	benchm.	
Metal-fraction	Pb-diss				Pb-diss				Pb-diss				Pb-diss				Pb-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.5	52	1.2	0.4	0.5	72	1.8	0.3	0.5	49	1.1	0.4	0.5	53	1.3	0.4	0.1	77	1.9	0.1
CC21	--				--				--				--				7.4	147	3.8	1.9
CC41	--				--				--				--				12.9	159	4.2	3.1
CC48	4.2	81	2.0	2.1	9.6	189	5.0	1.9	8.0	88	2.2	3.7	9.0	76	1.9	4.8	8.0	177	4.7	1.7
A68 (reference)	0.5	49	1.1	0.4	0.5	65	1.6	0.3	0.5	50	1.2	0.4	0.5	53	1.3	0.4	0.6	71	1.7	0.4
A72	0.5	45	1.0	0.5	0.5	78	1.9	0.3	0.5	54	1.3	0.4	0.5	55	1.3	0.4	0.05	86	2.1	0.0
Opp sample 1	--				--				--				--				0.05	86	2.1	0.0
Opp sample 2	--				--				--				--				0.05	87	2.2	0.0
Opp sample 3	--				--				--				--				0.05	88	2.2	0.0
Opp sample 4	--				--				--				--				0.05	87	2.2	0.0
Opp sample 5	--				--				--				--				0.05	86	2.1	0.0
Opp sample 6	--				--				--				--				0.05	85	2.1	0.0
Opp sample 7	--				--				--				--				0.05	88	2.2	0.0
Opp sample 8	--				--				--				--				0.05	86	2.1	0.0
Opp sample 9	--				--				--				--				0.05	86	2.1	0.0
Opp sample 10	--				--				--				--				0.05	87	2.2	0.0

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.		8/09	hardness	benchm.		9/09	hardness	benchm.		11/09	hardness	benchm.		7/10	hardness	benchm.	
Metal-fraction	Pb-diss				Pb-diss				Pb-diss				Pb-diss				Pb-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.5	91	2.3	0.2	0.5	186	4.9	0.1	0.5	156	4.1	0.1	0.5	238	6.4	0.1	0.5	114	2.9	0.2
CC48	13.0	293	7.9	1.6	16.8	467	12.8	1.3	14.5	470	12.9	1.1	16.2	495	13.6	1.2	17.4	345	9.4	1.9
A68 (reference)	0.5	85	2.1	0.2	0.5	135	3.5	0.1	0.5	141	3.7	0.1	0.5	167	4.4	0.1	0.5	97	2.4	0.2
A72	0.5	109	2.8	0.2	0.5	211	5.6	0.1	0.5	199	5.3	0.1	0.5	296	8.0	0.1	0.5	136	3.5	0.1

Sampling Date	9/10	hardness	benchm.		11/10	hardness	benchm.		7/11	hardness	benchm.		8/11	hardness	benchm.		9/11	hardness	benchm.		10/11	hardness	benchm.	
Metal-fraction	Pb-diss				Pb-diss				Pb-diss				Pb-diss				Pb-diss				Pb-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.1	199	5.3	0.0	0.1	219	5.8	0.0	0.5	65	1.6	0.3	0.5	144	3.7	0.1	0.5	188	5.0	0.1	0.5	155	4.0	0.1
CC48	16.8	509	14.0	1.2	17.1	517	14.2	1.2	8.5	191	5.1	1.7	19.2	398	10.9	1.8	21.4	474	13.0	1.6	18.7	435	11.9	1.6
A68 (reference)	0.1	144	3.7	0.0	0.1	154	4.0	0.0	0.5	66	1.6	0.3	0.5	111	2.8	0.2	0.5	140	3.6	0.1	0.5	138	3.6	0.1
A72	0.1	245	6.6	0.0	0.1	232	6.2	0.0	0.5	75	1.8	0.3	0.5	161	4.2	0.1	0.5	210	5.6	0.1	0.5	183	4.8	0.1

shadingshows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for lead was calculated using the following equation: (1.46203-[ln(hardness) * (0.145712)] * $e^{1.273[\ln(\text{hardness})]-4.705}$

Appendix 3.e: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Manganese Concentrations Measured in Surface Water Samples Collected Between 2009 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.		3/10	hardness	benchm.		4/10	hardness	benchm.		3/11	hardness	benchm.	
Metal-fraction	Mn-diss				Mn-diss				Mn-diss				Mn-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	630	309	2402	0.3	634	308	2399	0.3	324	150	1888	0.2	530	247	2229	0.2
CC48	5290	571	2947	1.8	5200	541	2895	1.8	3040	301	2381	1.3	4940	493	2806	1.8
A68 (reference)	3560	202	2085	1.7	2710	179	2003	1.4	3730	148	1880	2.0	3160	172	1976	1.6
A72	2710	352	2509	1.1	2920	337	2472	1.2	1770	177	1995	0.9	2340	273	2305	1.0

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.		6/09	hardness	benchm.		6/10	hardness	benchm.		6/11	hardness	benchm.		5/12	hardness	benchm.	
Metal-fraction	Mn-diss				Mn-diss				Mn-diss				Mn-diss				Mn-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	160	52	1327	0.1	120	72	1479	0.1	84.9	49	1301	0.1	150	53	1335	0.1	115	77	1512	0.1
CC21	--				--				--				--				2410	147	1875	1.3
CC41	--				--				--				--				1750	159	1925	0.9
CC48	766	81	1538	0.5	1770	189	2039	0.9	811	88	1581	0.5	731	76	1505	0.5	1620	177	1995	0.8
A68 (reference)	340	49	1301	0.3	636	65	1429	0.4	335	50	1309	0.3	415	53	1335	0.3	699	71	1472	0.5
A72	219	45	1264	0.2	450	78	1519	0.3	241	54	1343	0.2	305	55	1352	0.2	471	86	1569	0.3
Opp sample 1	--				--				--				--				483	86	1569	0.3
Opp sample 2	--				--				--				--				487	87	1575	0.3
Opp sample 3	--				--				--				--				486	88	1581	0.3
Opp sample 4	--				--				--				--				504	87	1575	0.3
Opp sample 5	--				--				--				--				488	86	1569	0.3
Opp sample 6	--				--				--				--				480	85	1563	0.3
Opp sample 7	--				--				--				--				483	88	1581	0.3
Opp sample 8	--				--				--				--				477	86	1569	0.3
Opp sample 9	--				--				--				--				477	86	1569	0.3
Opp sample 10	--				--				--				--				495	87	1575	0.3

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.		8/09	hardness	benchm.		9/09	hardness	benchm.		11/09	hardness	benchm.		7/10	hardness	benchm.	
Metal-fraction	Mn-diss				Mn-diss				Mn-diss				Mn-diss				Mn-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	169	91	1599	0.1	410	186	2028	0.2	336	156	1913	0.2	592	238	2202	0.3	212	114	1723	0.1
CC48	2830	293	2360	1.2	4810	467	2756	1.7	4920	470	2762	1.8	5270	495	2810	1.9	3280	345	2492	1.3
A68 (reference)	668	85	1563	0.4	1320	135	1823	0.7	1540	141	1850	0.8	2380	167	1957	1.2	649	97	1633	0.4
A72	603	109	1698	0.4	1420	211	2115	0.7	1370	199	2075	0.7	2490	296	2368	1.1	736	136	1828	0.4

Sampling Date	9/10	hardness	benchm.		11/10	hardness	benchm.		7/11	hardness	benchm.		8/11	hardness	benchm.		9/11	hardness	benchm.		10/11	hardness	benchm.	
Metal-fraction	Mn-diss				Mn-diss				Mn-diss				Mn-diss				Mn-diss				Mn-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	435	199	2075	0.2	456	219	2142	0.2	104	65	1429	0.1	293	144	1863	0.2	406	188	2036	0.2	303	155	1909	0.2
CC48	5030	509	2837	1.8	5220	517	2851	1.8	1740	191	2046	0.9	3890	398	2613	1.5	4900	474	2770	1.8	4620	435	2692	1.7
A68 (reference)	1310	144	1863	0.7	1790	154	1905	0.9	537	66	1436	0.4	821	111	1708	0.5	1140	140	1845	0.6	1310	138	1836	0.7
A72	1590	245	2223	0.7	1690	232	2183	0.8	405	75	1499	0.3	923	161	1933	0.5	1290	210	2112	0.6	1180	183	2017	0.6

shading shows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for manganese was calculated using the following equation: $e^{(0.3331[\ln(\text{hardness})]+5.8743)}$

Appendix 3.f: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Nickel Concentrations Measured in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.	HQ	3/10	hardness	benchm.	HQ	4/10	hardness	benchm.	HQ	3/11	hardness	benchm.	HQ
Metal-fraction	Ni-diss				Ni-diss				Ni-diss				Ni-diss			
Units	ug/L				µg/L				µg/L				µg/L			
M34	5.3	309	135	0.04	3.3	308	135	0.02	1.0	150	73	0.01	4.0	247	112	0.04
CC48	19.4	571	227	0.09	16.3	541	217	0.08	10.3	301	132	0.08	16.4	493	201	0.08
A68 (reference)	1.0	202	94	0.01	1.0	179	85	0.01	1.0	148	72	0.01	2.0	172	82	0.02
A72	8.2	352	151	0.05	6.4	337	145	0.04	3.4	177	84	0.04	5.8	273	122	0.05

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.	HQ	6/09	hardness	benchm.	HQ	6/10	hardness	benchm.	HQ	6/11	hardness	benchm.	HQ	5/12	hardness	benchm.	HQ
Metal-fraction	Ni-diss				Ni-diss				Ni-diss				Ni-diss				Ni-diss			
Units	ug/L				µg/L				µg/L				µg/L				µg/L			
M34	1.0	52	30	0.03	1.0	72	39	0.03	2.0	49	28	0.07	2.0	53	30	0.07	0.6	77	42	0.02
CC21	--				--				--				--				4.3	147	72	0.06
CC41	--				--				--				--				5.3	159	77	0.07
CC48	2.2	81	44	0.05	5.3	189	89	0.06	2.0	88	47	0.04	2.0	76	41	0.05	4.9	177	84	0.06
A68 (reference)	1.0	49	28	0.04	1.0	65	36	0.03	2.0	50	29	0.07	2.0	53	30	0.07	0.3	71	39	0.01
A72	1.0	45	26	0.04	1.0	78	42	0.02	2.0	54	31	0.06	2.0	55	31	0.06	0.9	86	46	0.02
Opp sample 1	--				--				--				--				0.7	86	46	0.01
Opp sample 2	--				--				--				--				0.7	87	46	0.01
Opp sample 3	--				--				--				--				0.8	88	47	0.02
Opp sample 4	--				--				--				--				0.7	87	46	0.02
Opp sample 5	--				--				--				--				0.7	86	46	0.01
Opp sample 6	--				--				--				--				0.6	85	45	0.01
Opp sample 7	--				--				--				--				0.8	88	47	0.02
Opp sample 8	--				--				--				--				0.6	86	46	0.01
Opp sample 9	--				--				--				--				0.7	86	46	0.02
Opp sample 10	--				--				--				--				0.7	87	46	0.02

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.	HQ	8/09	hardness	benchm.	HQ	9/09	hardness	benchm.	HQ	11/09	hardness	benchm.	HQ	7/10	hardness	benchm.	HQ
Metal-fraction	Ni-diss				Ni-diss				Ni-diss				Ni-diss				Ni-diss			
Units	µg/L				µg/L				µg/L				µg/L				µg/L			
M34	1.0	91	48	0.02	2.1	186	88	0.02	2.3	156	76	0.03	4.1	238	108	0.04	2.0	114	58	0.03
CC48	9.1	293	129	0.07	15.0	467	192	0.08	15.7	470	193	0.08	17.4	495	201	0.09	8.6	345	148	0.06
A68 (reference)	1.0	85	45	0.02	1.0	135	67	0.01	1.0	141	70	0.01	1.0	167	80	0.01	2.0	97	51	0.04
A72	1.0	109	56	0.02	3.0	211	98	0.03	3.7	199	93	0.04	6.4	296	130	0.05	2.0	136	67	0.03

Sampling Date	9/10	hardness	benchm.	HQ	11/10	hardness	benchm.	HQ	7/11	hardness	benchm.	HQ	8/11	hardness	benchm.	HQ	9/11	hardness	benchm.	HQ	10/11	hardness	benchm.	HQ
Metal-fraction	Ni-diss				Ni-diss				Ni-diss				Ni-diss				Ni-diss				Ni-diss			
Units	µg/L				µg/L				µg/L				µg/L				µg/L				µg/L			
M34	0.4	199	93	0.00	0.4	219	101	0.00	2.0	65	36	0.06	2.0	144	71	0.03	2.0	188	89	0.02	2.0	155	75	0.03
CC48	16.5	509	206	0.08	16.2	517	209	0.08	6.0	191	90	0.07	13.0	398	167	0.08	14.5	474	194	0.07	13.7	435	180	0.08
A68 (reference)	0.4	144	71	0.00	0.4	154	75	0.00	2.0	66	37	0.05	2.0	111	57	0.04	2.0	140	69	0.03	2.0	138	68	0.03
A72	0.4	245	111	0.00	4.2	232	106	0.04	2.0	75	41	0.05	2.0	161	78	0.03	2.0	210	97	0.02	2.0	183	87	0.02

shading shows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for nickel was calculated using the following equation: $e^{0.846[\ln(\text{hardness})]+0.0554}$

Appendix 3.g: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Silver Concentrations Measured in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.		3/10	hardness	benchm.		4/10	hardness	benchm.		3/11	hardness	benchm.	
Metal-fraction	Ag-diss				Ag-diss				Ag-diss				Ag-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.6	309	0.52	1.1	0.5	308	0.52	1.0	0.25	150	0.15	1.7	0.25	247	0.36	0.7
CC48	0.25	571	1.50	0.2	0.25	541	1.37	0.2	0.25	301	0.50	0.5	0.25	493	1.17	0.2
A68 (reference)	0.25	202	0.25	1.0	0.25	179	0.20	1.2	0.25	148	0.15	1.7	0.25	172	0.19	1.3
A72	0.25	352	0.65	0.4	0.25	337	0.61	0.4	0.25	177	0.20	1.2	0.25	273	0.42	0.6

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.		6/09	hardness	benchm.		6/10	hardness	benchm.		6/11	hardness	benchm.		5/12	hardness	benchm.	
Metal-fraction	Ag-diss				Ag-diss				Ag-diss				Ag-diss				Ag-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.25	52	0.02	10.3	0.25	72	0.04	5.9	0.25	49	0.02	11.4	0.25	53	0.03	9.9	0.25	77	0.05	5.2
CC21	--				--				--				--				0.25	147	0.15	1.7
CC41	--				--				--				--				0.25	159	0.17	1.5
CC48	0.25	81	0.05	4.8	0.25	189	0.22	1.1	0.25	88	0.06	4.1	0.25	76	0.05	5.3	0.25	177	0.20	1.2
A68 (reference)	0.25	49	0.02	11.4	0.25	65	0.04	7.0	0.25	50	0.02	11.0	0.25	53	0.03	9.9	0.25	71	0.04	6.0
A72	0.25	45	0.02	13.1	0.25	78	0.05	5.1	0.25	54	0.03	9.6	0.25	55	0.03	9.3	0.25	86	0.06	4.3
Opp sample 1	--				--				--				--				0.25	86	0.06	4.3
Opp sample 2	--				--				--				--				0.25	87	0.06	4.2
Opp sample 3	--				--				--				--				0.25	88	0.06	4.1
Opp sample 4	--				--				--				--				0.25	87	0.06	4.2
Opp sample 5	--				--				--				--				0.25	86	0.06	4.3
Opp sample 6	--				--				--				--				0.25	85	0.06	4.4
Opp sample 7	--				--				--				--				0.25	88	0.06	4.1
Opp sample 8	--				--				--				--				0.25	86	0.06	4.3
Opp sample 9	--				--				--				--				0.25	86	0.06	4.3
Opp sample 10	--				--				--				--				0.25	87	0.06	4.2

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.		8/09	hardness	benchm.		9/09	hardness	benchm.		11/09	hardness	benchm.		7/10	hardness	benchm.	
Metal-fraction	Ag-diss				Ag-diss				Ag-diss				Ag-diss				Ag-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.25	91	0.06	3.9	0.25	186	0.22	1.1	0.25	156	0.16	1.5	0.25	238	0.33	0.7	0.25	114	0.09	2.7
CC48	0.25	293	0.48	0.5	0.25	467	1.06	0.2	0.25	470	1.08	0.2	0.25	495	1.18	0.2	0.25	345	0.63	0.4
A68 (reference)	0.25	85	0.06	4.4	0.25	135	0.13	2.0	0.25	141	0.14	1.8	0.25	167	0.18	1.4	0.25	97	0.07	3.5
A72	0.25	109	0.09	2.9	0.25	211	0.27	0.9	0.25	199	0.25	1.0	0.25	296	0.49	0.5	0.25	136	0.13	2.0

Sampling Date	9/10	hardness	benchm.		11/10	hardness	benchm.		7/11	hardness	benchm.		8/11	hardness	benchm.		9/11	hardness	benchm.		10/11	hardness	benchm.	
Metal-fraction	Ag-diss				Ag-diss				Ag-diss				Ag-diss				Ag-diss				Ag-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	0.05	199	0.25	0.2	0.05	219	0.29	0.2	0.25	65	0.04	7.0	0.25	144	0.14	1.8	0.25	188	0.22	1.1	0.25	155	0.16	1.6
CC48	0.05	509	1.23	0.04	0.05	517	1.27	0.04	0.25	191	0.23	1.1	0.25	398	0.81	0.3	0.25	474	1.09	0.2	0.25	435	0.94	0.3
A68 (reference)	0.05	144	0.14	0.4	0.05	154	0.16	0.3	0.25	66	0.04	6.8	0.25	111	0.09	2.8	0.25	140	0.13	1.9	0.25	138	0.13	1.9
A72	0.05	245	0.35	0.1	0.05	232	0.32	0.2	0.25	75	0.05	5.5	0.25	161	0.17	1.5	0.25	210	0.27	0.9	0.25	183	0.21	1.2

shading shows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for silver was calculated using the following equation: $e^{(1.72[\ln(hardness)]-10.51)}$

Appendix 3.h: Calculating Hardness-Specific Benchmarks and HQs for Dissolved Zinc Concentrations Measured in Surface Water Samples Collected Between 2009 and 2012
Screening-Level Ecological Risk Assessment
Upper Animas Mining District

PRE-RUNOFF PERIOD

Sampling Date	2/10	hardness	benchm.		3/10	hardness	benchm.		4/10	hardness	benchm.		3/11	hardness	benchm.	
Metal-fraction	Zn-diss				Zn-diss				Zn-diss				Zn-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	328	309	325	1.0	292	308	324	0.9	499	150	176	2.8	312	247	269	1.2
CC48	2670	571	549	4.9	2600	541	524	5.0	1600	301	318	5.0	2340	493	484	4.8
A68 (reference)	702	202	226	3.1	610	179	204	3.0	985	148	174	5.7	874	172	197	4.4
A72	1110	352	363	3.1	1230	337	350	3.5	864	177	202	4.3	972	273	293	3.3

RUNOFF PERIOD

Sampling Date	5/09	hardness	benchm.		6/09	hardness	benchm.		6/10	hardness	benchm.		6/11	hardness	benchm.		5/12	hardness	benchm.	
Metal-fraction	Zn-diss				Zn-diss				Zn-diss				Zn-diss				Zn-diss			
Units	ug/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	48.1	52	71	0.7	72.5	72	94	0.8	68.6	49	68	1.0	25.0	53	72	0.3	68.2	77	99	0.7
CC21	--				--				--				--				1710	147	173	9.9
CC41	--				--				--				--				1230	159	185	6.7
CC48	611	81	104	5.9	1080	189	214	5.0	660	88	111	5.9	614	76	98	6.2	1070	177	202	5.3
A68 (reference)	295	49	68	4.4	270	65	86	3.1	286	50	69	4.2	274	53	72	3.8	281	71	93	3.0
A72	133	45	63	2.1	249	78	101	2.5	206	54	74	2.8	217	55	75	2.9	284	86	109	2.6
Opp sample 1	--				--				--				--				278	86	109	2.5
Opp sample 2	--				--				--				--				285	87	110	2.6
Opp sample 3	--				--				--				--				282	88	111	2.5
Opp sample 4	--				--				--				--				290	87	110	2.6
Opp sample 5	--				--				--				--				284	86	109	2.6
Opp sample 6	--				--				--				--				290	85	108	2.7
Opp sample 7	--				--				--				--				287	88	111	2.6
Opp sample 8	--				--				--				--				282	86	109	2.6
Opp sample 9	--				--				--				--				287	86	109	2.6
Opp sample 10	--				--				--				--				302	87	110	2.7

POST-RUNOFF PERIOD

Sampling Date	7/09	hardness	benchm.		8/09	hardness	benchm.		9/09	hardness	benchm.		11/09	hardness	benchm.		7/10	hardness	benchm.	
Metal-fraction	Zn-diss				Zn-diss				Zn-diss				Zn-diss				Zn-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	88.7	91	115	0.8	180	186	211	0.9	175	156	182	1.0	317	238	260	1.2	106	114	139	0.8
CC48	1620	293	311	5.2	2650	467	462	5.7	2570	470	465	5.5	2650	495	486	5.5	1800	345	357	5.0
A68 (reference)	268	85	108	2.5	332	135	161	2.1	407	141	167	2.4	567	167	192	2.9	261	97	121	2.2
A72	313	109	134	2.3	636	211	235	2.7	617	199	223	2.8	1120	296	314	3.6	392	136	162	2.4

Sampling Date	9/10	hardness	benchm.		11/10	hardness	benchm.		7/11	hardness	benchm.		8/11	hardness	benchm.		9/11	hardness	benchm.		10/11	hardness	benchm.	
Metal-fraction	Zn-diss				Zn-diss				Zn-diss				Zn-diss				Zn-diss				Zn-diss			
Units	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ	µg/L			HQ
M34	196	199	223	0.9	242	219	242	1.0	54.4	65	86	0.6	131	144	170	0.8	170	188	213	0.8	142	155	181	0.8
CC48	2730	509	498	5.5	2890	517	504	5.7	1090	191	216	5.1	2140	398	404	5.3	2430	474	468	5.2	2400	435	435	5.5
A68 (reference)	410	144	170	2.4	436	154	180	2.4	237	66	87	2.7	282	111	136	2.1	311	140	166	1.9	393	138	164	2.4
A72	762	245	267	2.9	754	232	255	3.0	228	75	97	2.3	467	161	187	2.5	590	210	234	2.5	549	183	208	2.6

shading shows HQs > 1.0

note: the hardness-specific chronic surface water benchmark for zinc was calculated using the following equation: $0.986 * e^{0.8525[\ln(\text{hardness})]+0.9109}$